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August 1995 Vol.19 No.8
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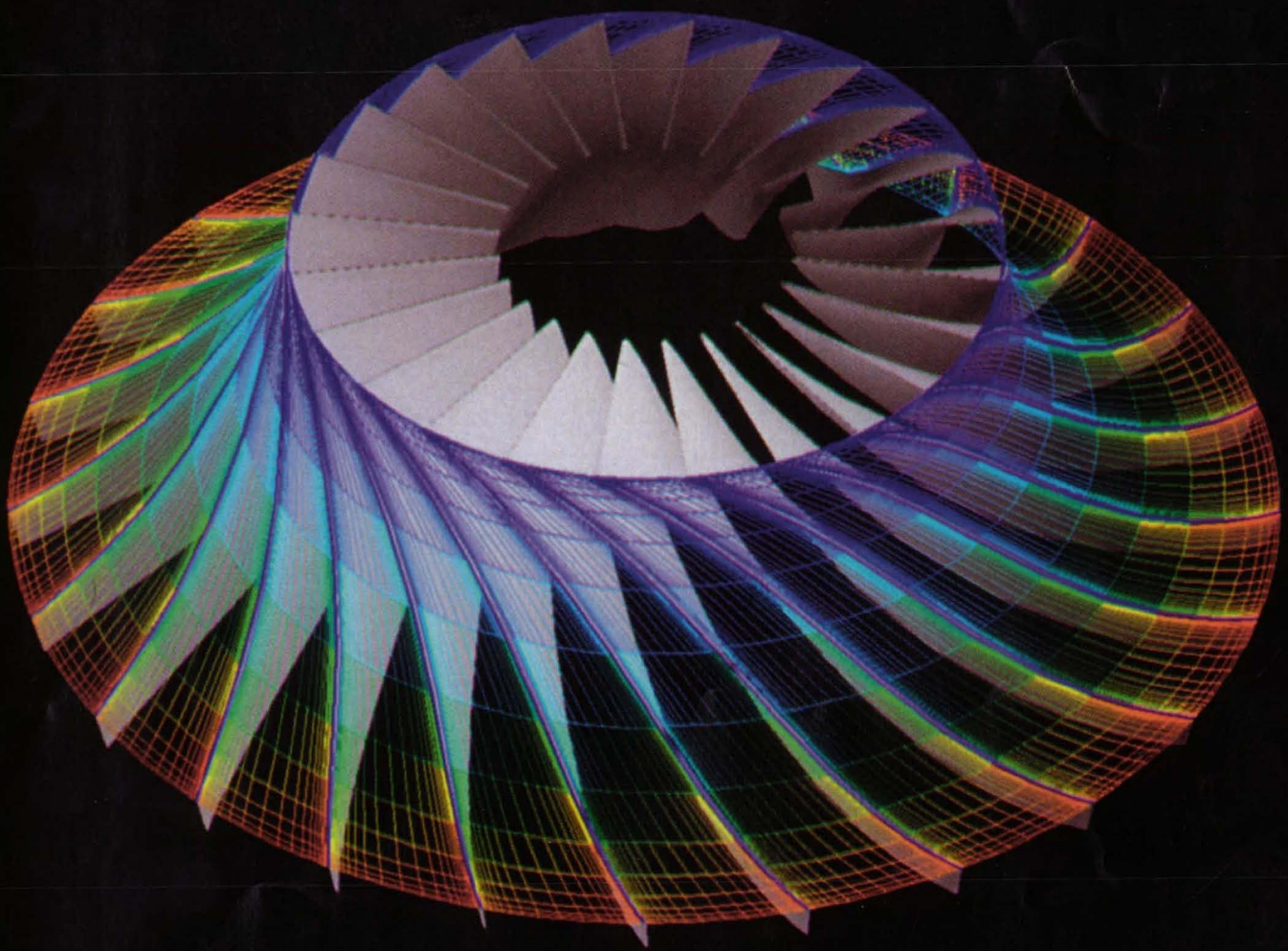
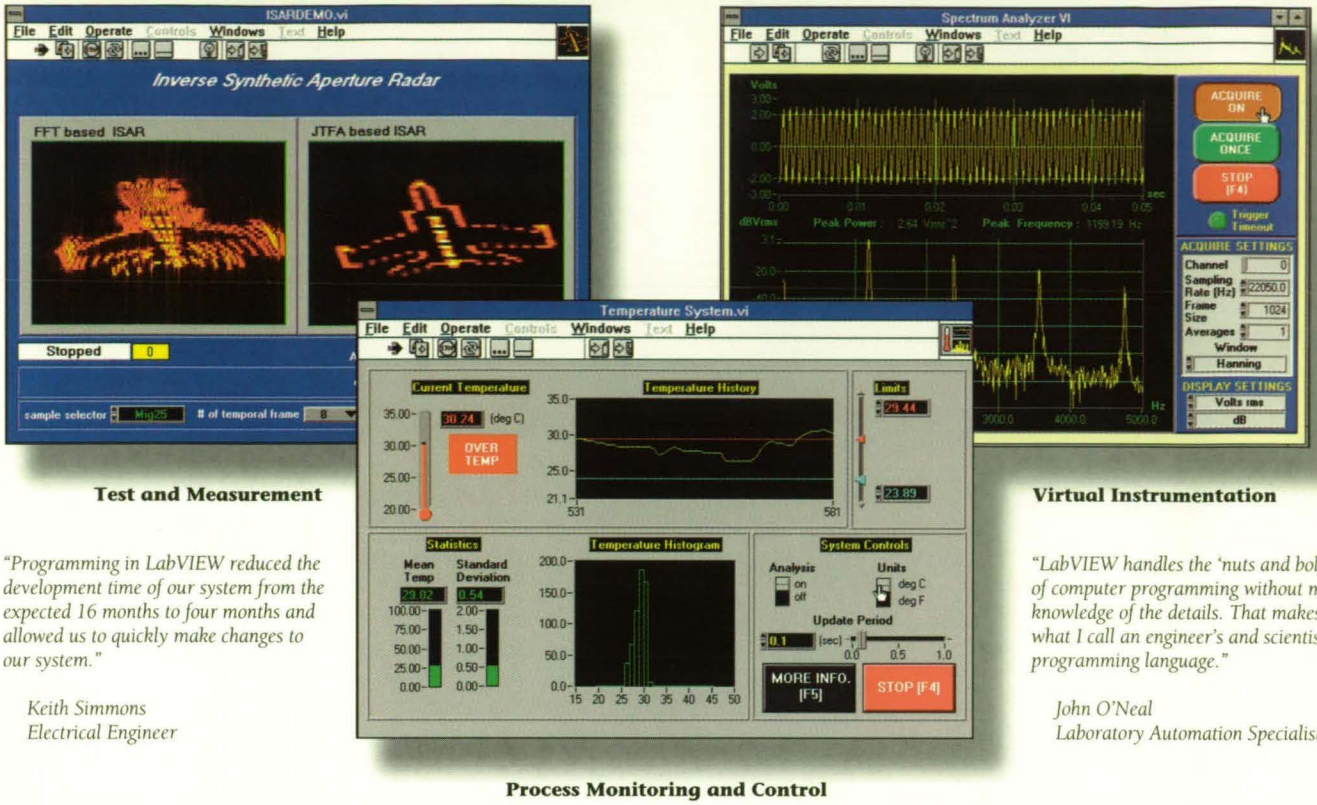
High-Tech Tool Aids Oklahoma City Rescue





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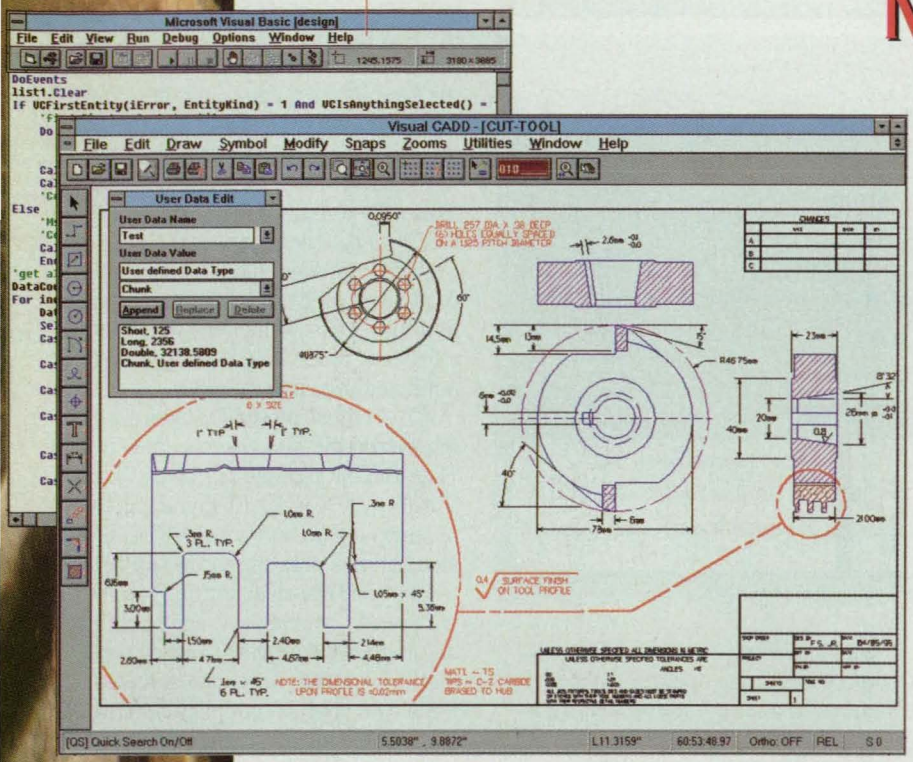

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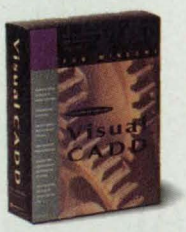

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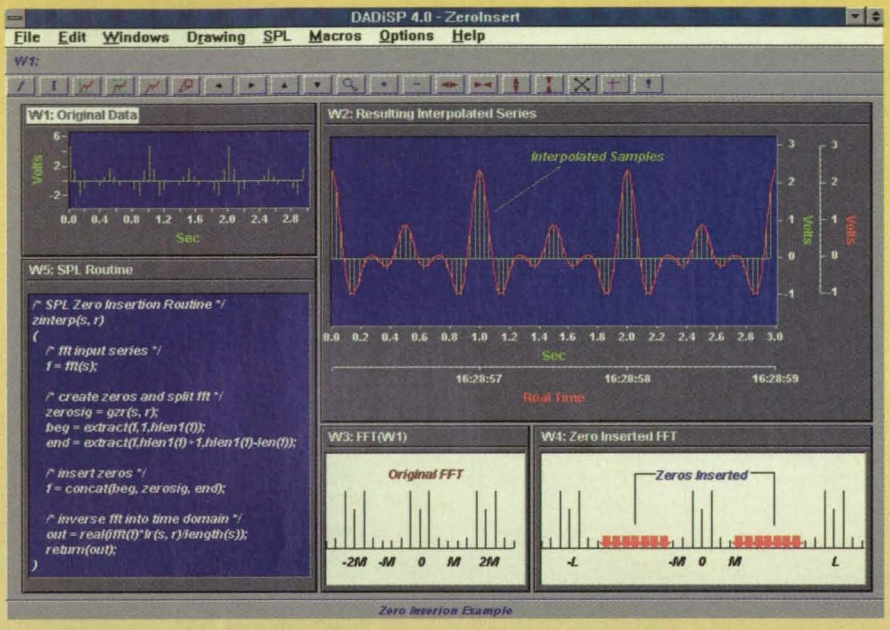
IN CASE YOU MISSED IT!

Here's what they* said about DADiSP 4.0

A streamlined user interface that fully conforms to Windows is the first obvious feature of a long-awaited upgrade to DADiSP, a graphical analysis program from DSP Development Corp. that's designed for the needs of scientists and engineers.



Zero Insertion Example

A major overhaul of the user interface, the introduction of an integrated programming language and new option modules highlight Ver. 4.0 of DADiSP...

Besides adopting a complete Windows look and feel, the overall interface scheme has gained a more streamlined look... [W]ith the flattened hierarchy on this upgrade, the software always starts up in a worksheet; indeed, when loaded, the software returns to the setup that was on the screen when the user last exited the program. Although you don't have to go through a hierarchy, the package still maintains labbooks, datasets and worksheets to provide a simple method of organizing large complex datafiles and projects.

As part of the Windows implementation, Ver. 4.0 adds support for DDE as a client or server either with functions at the command line or with Copy/Paste Link for the pulldown menu. It performs both warm and hot DDE links with either ASCII or binary datatypes...

Ver. 4.0 also gives users the ability to define their own operations and functions to a far greater extent than the macros found in the previous version. Specifically, the upgrade marks the introduction of a programming language called SPL (series processing language). Modeled on C, it provides all the expected facilities including user-defined functions, looping and iteration, conditional statements, array references and variables. Variables can be global to a session or local to a function.

An interesting feature is the hot variable, which can contain real or complex numbers, strings, data series and matrices. A hot variable links a formula to a variable so that when a dependent element of a formula changes, the hot variable automatically reevaluates. For example, the SPL code fragment:

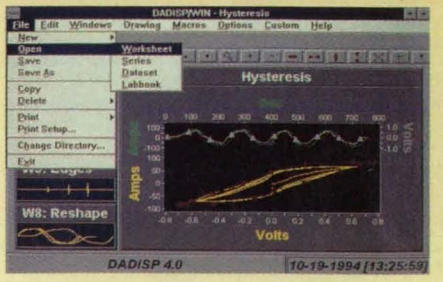
```
size := 10
W2: Movavg(W1, size)
```

performs a 10-point moving average on the waveform in Window 1 and displays the results in Window 2. The := operator establishes the hot variable. You can explore the effects of changing the moving-average length simply by reassigning size := 20 so that W2 automatically updates and shows a plot based on that new parameter.

Also improved is the package's hardcopy facility. Plot titles, legends, multiple scales, selectable fonts and a Preview mode help users produce publication-quality output...

[T]wo more modules... address advanced DSP and control applications. The AdvDSP module performs Chirp-Z transforms, N-point FFTs independent of series length and zoom FFTs. It also handles multiple forms of PSD estimation (classical, autoregressive parametric, moving-average parametric, autoregressive moving-average parametric), transfer-function estimates, Cepstrum analysis and digital interpolation. The controls module allows you to execute command line or pulldown menus, and it addresses the design, analysis and simulation of digital and continuous open- and closed-loop controllers for linear single-input/single-output dynamic systems. Among its algorithms are those that handle PID loops as well as lead and lag controllers.

* Personal Engineering & Instrumentation News 1/95



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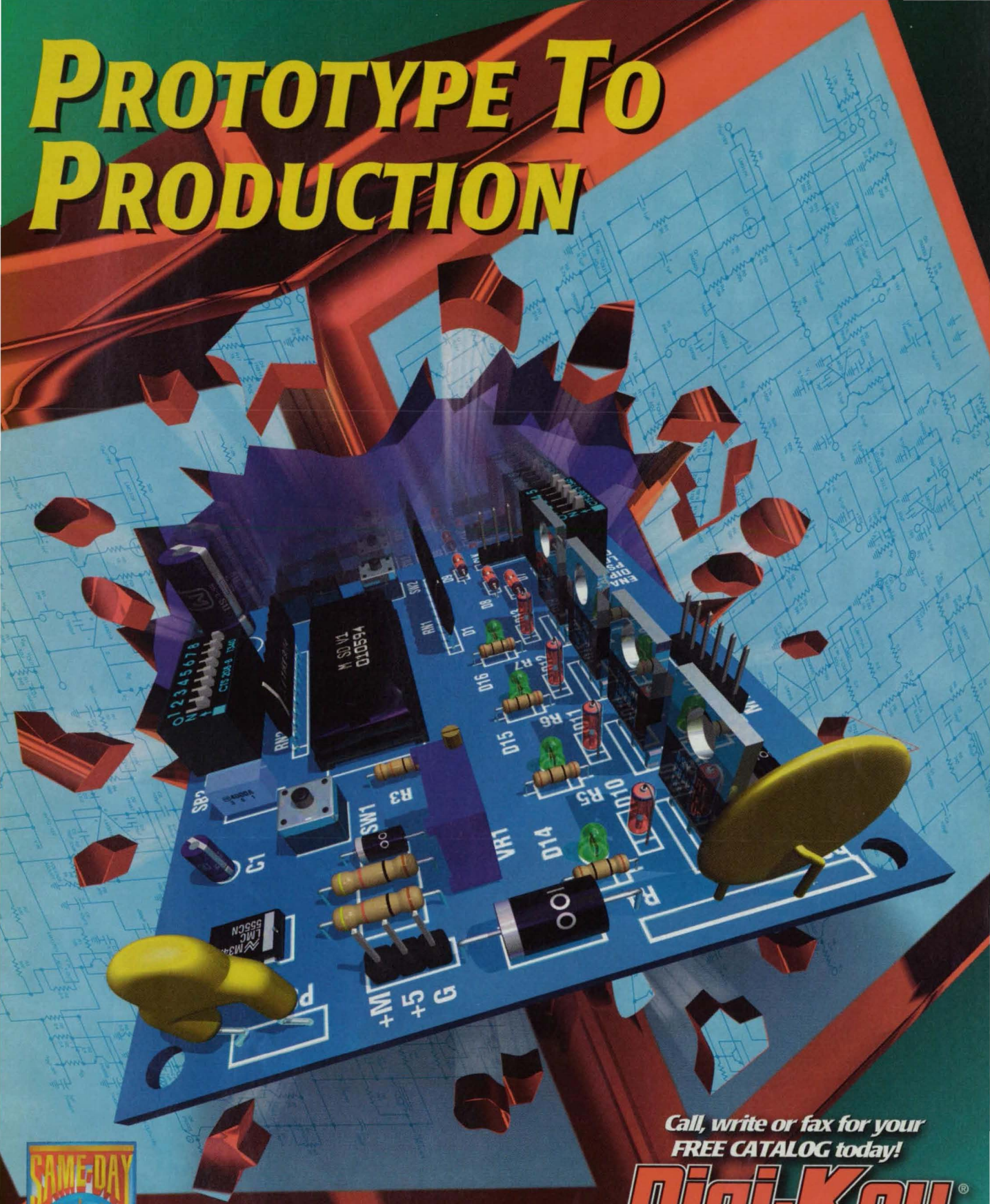

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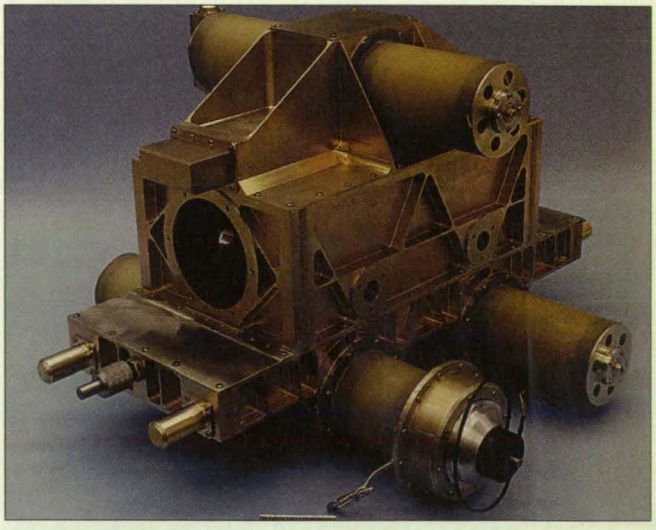

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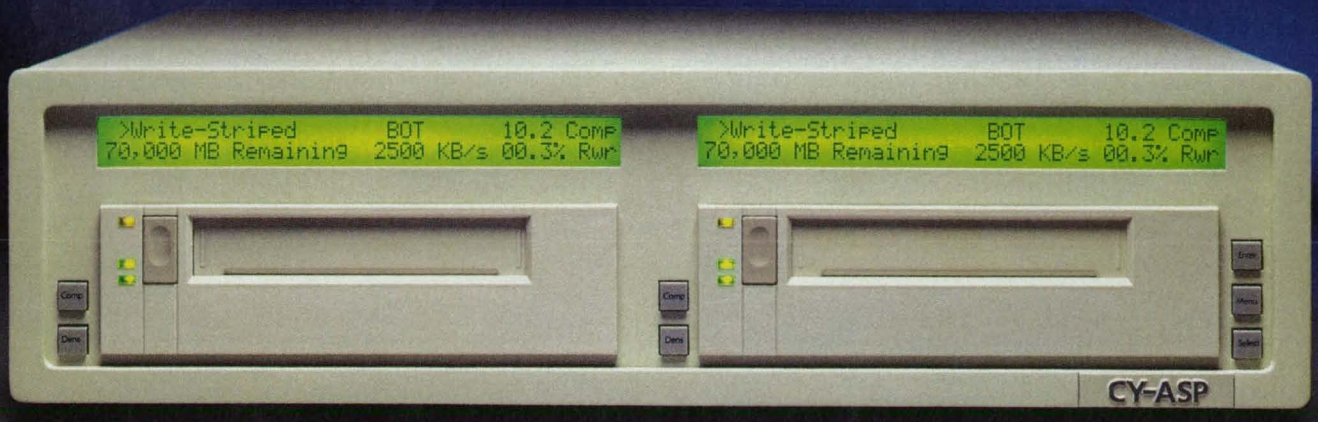

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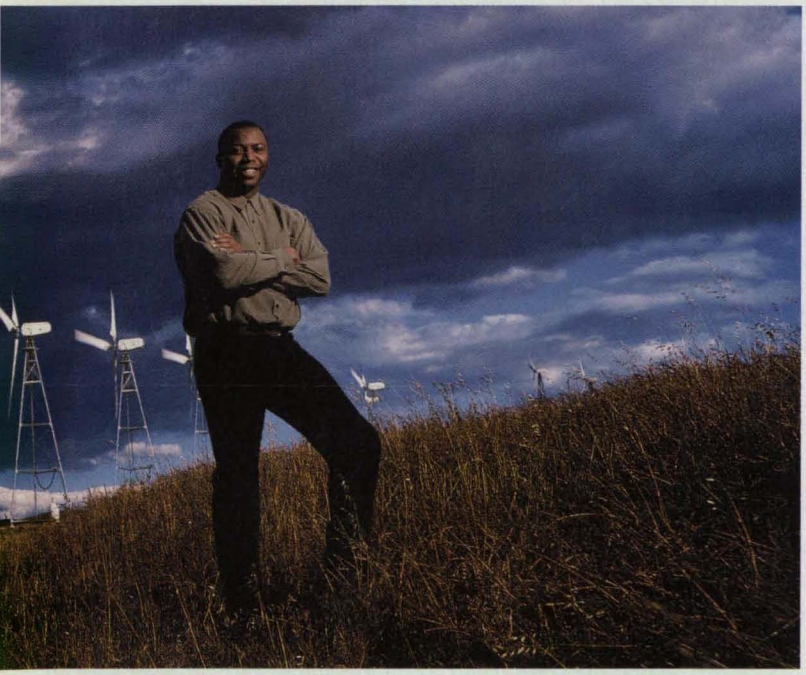

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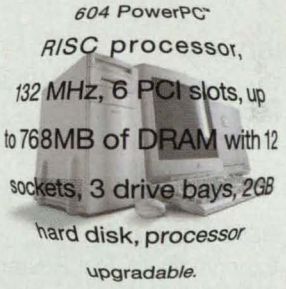

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1A–21A Laser Tech Briefs

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On the cover:

Various NASA facilities are using an interactive CFD post processing package called Fieldview from Intelligent Light (Lyndhurst, NJ) that enables scientists to study complex, 3D fluid dynamics datasets. Depicted is the pressure rise along the shroud of a 30-degree backswept impeller with 24 blades, rotating at 22,363 rpm, that was analyzed with Fieldview. The data was provided by Northern Research Engineering Corp. (Woburn, MA).

Photo courtesy of Intelligent Light

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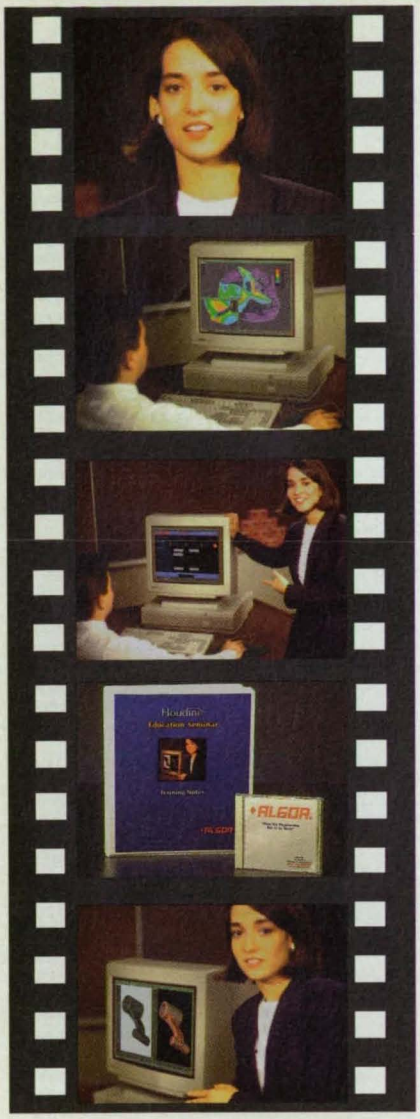

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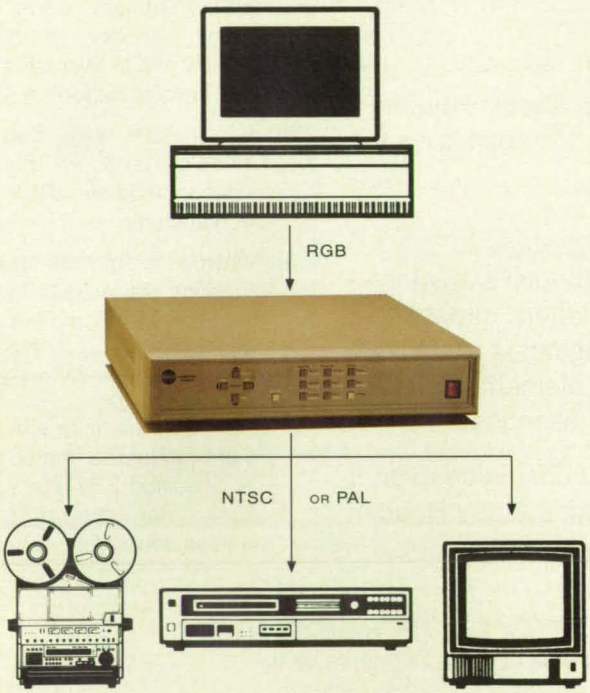

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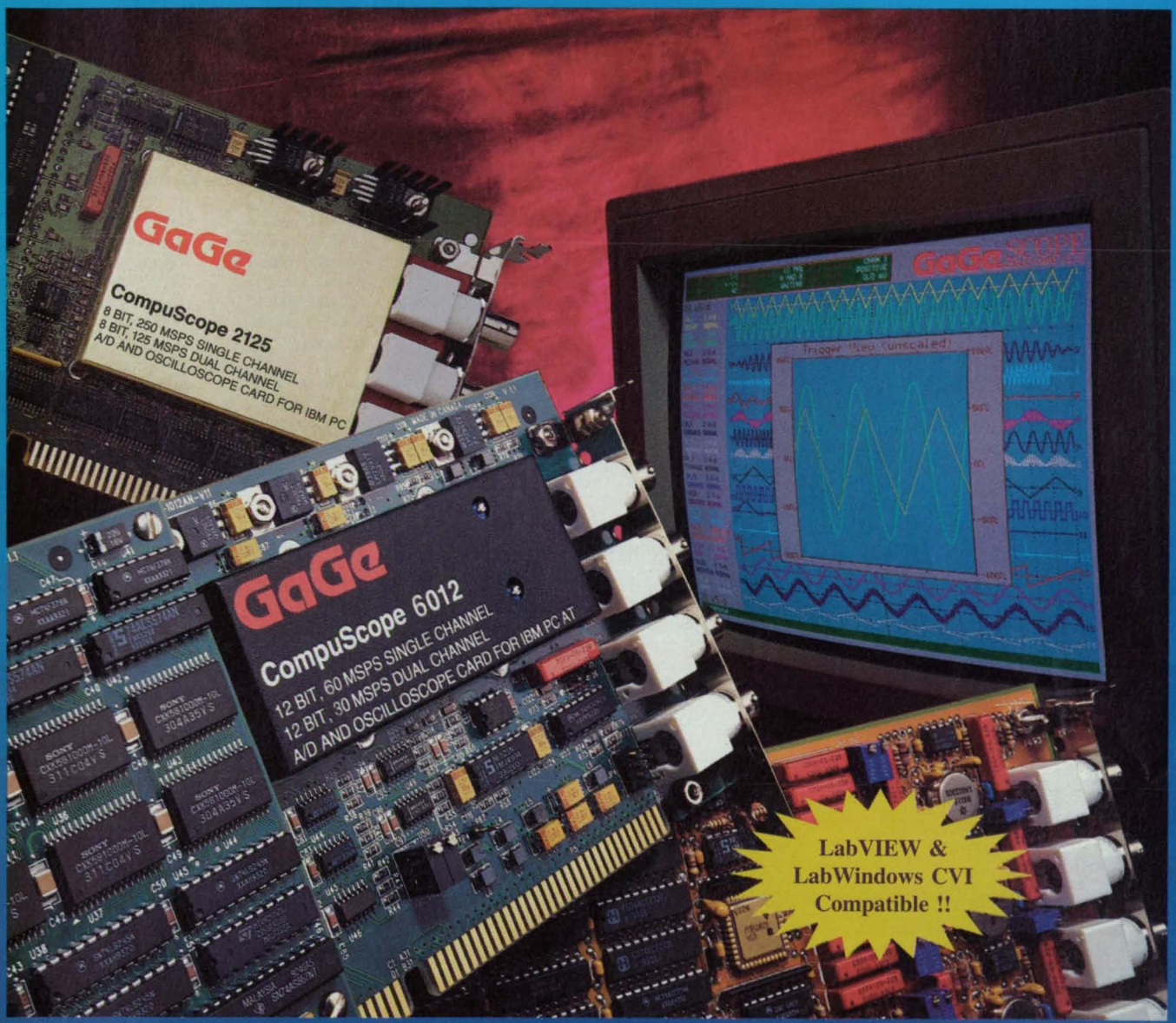

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NASA PATENTS

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Water-Driven Turbine/Brush Pipe Cleaner

(U.S. Patent No. 5,406,666)

Inventor: Rudy J. Werlink, Kennedy Space Center

To clean contaminant buildup in pipe walls, common methods have involved environmentally damaging freon solvents, which will soon be phased out by law, or a circular brush driven by a longitudinal shaft connected to a motor, limited by 90-degree turns in the pipe and by tube width. Mr. Werlink designed a brush-turbine assembly that employs the pipe's regular fluid flow to drive the apparatus through the pipe, disposes of the need for freon, and negotiates 90-degree bends.

For More Information Write In No. 744

Leak Detection Utilizing Analog Binaural (VLSI) Technique

(U.S. Patent No. 5,417,113)

Inventor: Frank T. Hartley, Jet Propulsion Laboratory

Using acoustic methods to detect leaks in pipes, or any structure supporting standing-wave propagation, runs into problems when there are overwhelming levels of background noise. To overcome such noise, Mr. Hartley's detection device employs a very large scale integration (VLSI) circuit constituting the traveling-wave structure of the human cochlea to derive spatial and spectral information in a 2-D plane, and calculates several representations of these planes to render a 3-D stereausis representation.

For More Information Write In No. 741

Particle Fallout/Activity Sensor

(U.S. Patent No. 5,412,221)

Inventors: Ihlefield M. Curtis, Robert C. Youngquist, John S. Moerk, and Kenneth A. Rose, Kennedy Space Center

In measuring particle fallout, such as dust and fibers, in a particle-sensitive area, knowing the timing of the accumulation and how much was accumulated in an interval can help pinpoint when potentially destructive events occur. Current methods such as witness plates for collecting material for laboratory examination restrict fallout measurements to an accumulation account over an extended time. The present invention digitizes accumulation data from an optical particle sensing system and sends it to a data-acquisition module with a timekeeper to keep track of the timing of different levels of accumulation.

For More Information Write In No. 743

Method for Determining Surface Coverage by Materials Exhibiting Different Fluorescent Properties

(U.S. Patent No. 5,412,219)

Inventor: Emmett W. Chappelle, Craig S.T. Daughtry, and James E. McMurtrey, III, Goddard Space Flight Center

Maintaining as little as 30% of a crop's residue—the dead part of a crop left in the field after harvest—can reduce soil erosion by about 90%. The present invention allows a quick, accurate, and objective way to measure the crop residue by irradiating the surface with ultraviolet radiation, detecting the fluorescent emission, characterizing the emission's spectral content, and calculating the surface covered by living plants, dead vegetation, and soil. This method has advantages over previous photographic and intercept techniques, which are slow and to some degree subjective.

For More Information Write In No. 742

Crystalline Imide/Arylene Ether Copolymers

(U.S. Patent No. 5,418,300)

Inventors: Brian J. Jensen, Paul. M. Hergenrother, and Robert G. Bass, Langley Research Center

Poly(arylene ethers) have good mechanical properties, thermo-oxidative stability, relative ease of processing, and solubility in common solvents; wholly aromatic polyimides have exceptional thermal, thermooxidative, and chemical resistance; and crystallinity in a polymer improves solvent-resistance, increases the modulus, and may increase toughness. The new crystalline imide/arylene ether copolymers developed at Langley combine many of these properties. At 25° C, solution cast films of the block copolymers had tensile strength up to 16,200 psi, tensile moduli up to 535,000 psi, and elongation at break up to 8%.

For More Information Write In No. 745

Forback DC-to-DC Converter

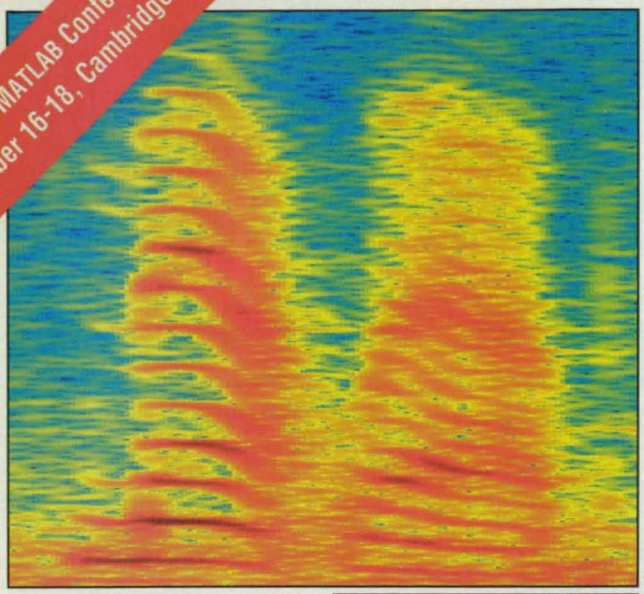
(U.S. Patent No. 5,418,709)

Inventor: Alan T. Lukemire, Goddard Space Flight Center

DC-to-DC power converters use a switching device and a combination of inductors and capacitors to derive power from one source of DC voltage and deliver it to a load at the same or different DC voltage. Mr. Lukemire made a relatively simple DC-to-DC converter topology through the particular location of the current-sensing transformer and the use of equal-valued first and second inductors. This pulse-width modulated converter has current mode control and provides both volt-second balance of the power transformer and ampere-second balance of the current-sensing transformer simultaneously.

For More Information Write In No. 746

1995 MATLAB Conference
October 16-18, Cambridge, MA



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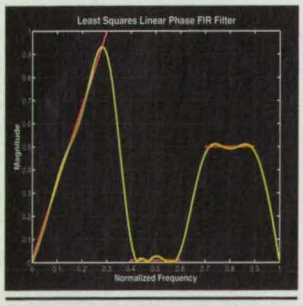

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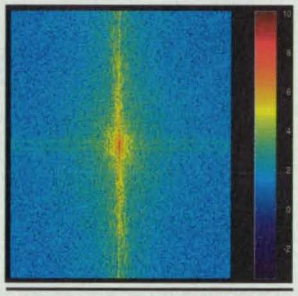

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New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Commercial Technology Office of the sponsoring NASA center (see page 14).

Improved Controllers for Heaters in Toxic-Gas Combustors

Electronic proportional controllers maintain electric heaters in toxic-gas combustors at precise preset temperatures. This measure eliminates excess power consumption and stressful on/off cycling that were encountered with previous mechanical controllers (See page 33.)

Replacements for Ozone-Depleting Foaming Agents

Two fluorinated ethers are being investigated as potential replacements of blowing agents that are currently used in the manufacture of polyurethane foam. These ethers do not have ozone depletion potential and can be used in existing foam-producing equipment. (See page 50.)

Hardware and Software for Development of Robot Arms

A system of modular, reusable hardware and software has been assembled for use in developing remotely controlled robotic arms. The system consists mostly of commercial products. (See page 45.)

Universal Controller for Supersonic Engine Inlet

Engine-demand airflow would be used as the primary control parameter in an advanced supersonic airplane. Advantages include design and installation of upgraded engines requiring practically no changes in the hardware and software of air-inlet controllers, fewer air-inlet controllers, and enhanced supportability and maintainability of the aircraft. (See page 63.)

Hydrophobic, Porous Battery Boxes

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Burt Rutan Makes Vellum Fly

Two years after the Voyager completed its record-shattering around-the-world flight, you could still find its designer, Burt Rutan, working at a drafting table with pencil and paper.

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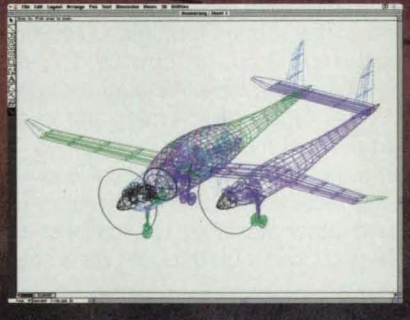

Burt's creativity and willingness to explore uncharted territory is exemplified by this sneak peek at one of his latest designs produced (of course) in Vellum.

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Mission Accomplished

The television crews captured the drama. A two-ton slab of concrete hung from the roof of the Murrah Federal Office Building by a one-inch piece of reinforced bar, threatening the rescue workers below. A firefighter climbed to the roof, hooked the cutter section of a special instrument around the reinforced bar, pulled back on the actuation handle and depressed the trigger. Instantly, the two-ton slab dropped six stories, allowing rescuers to continue their lifesaving work.

Lifeshear, the instrument behind this 30-second action in Oklahoma City last April, was developed through an Advanced Research Project Agency-funded, multiple-agency-sponsored Technology Reinvestment Project (TRP) award managed by NASA, in conjunction with the manufacturer, Hi-Shear Technology Corp. of Torrance, CA, and the City of Torrance. Although designed to sever automotive brake and clutch pedals and roof posts and pillars for removing an automobile's roof and rescuing accident victims, Lifeshear has found other lifesaving applications. The tool also can cut through water pipe, electrical conduit, reinforced bar, and other structural components of buildings, and provides life-saving assists in fire-department rescue situations involving occupants trapped in their homes.

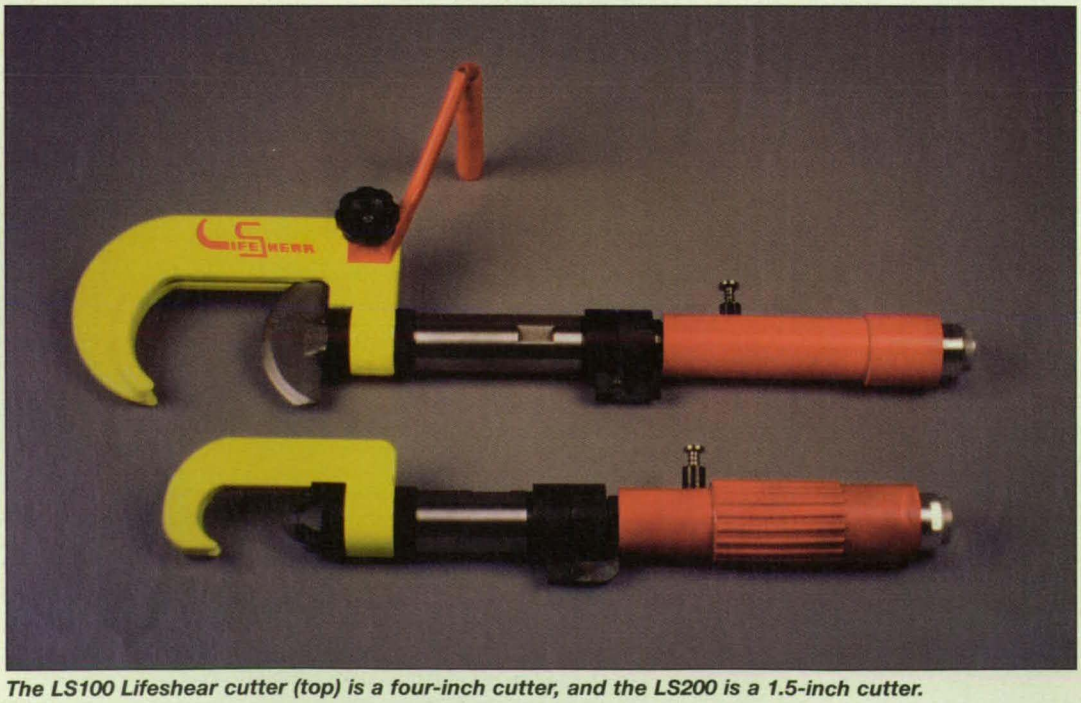
NASA teamed with Hi-Shear and the City of Torrance Fire Department to develop an earlier-model extraction tool into a new one for automotive rescues. In Oklahoma City, the new tool drew the attention of Federal Emergency Management Agency officials. After rescue workers in Oklahoma City used it to penetrate building materials and rescue trapped victims, FEMA officials ordered 36 cutters and 6400 power units and trained rescue teams in the tool's use. FEMA has also recommended its use by all Urban Search and Rescue groups across the nation.

What raises this cutter above its predecessor is the power unit, based on NASA-developed pyrotechnics. Called initiators, they look like a shell, or cartridge, and are loaded into the tool like a shell into a gun. The power unit generates hot gases that drive the blade through the target, whereas the earlier extractors employed expensive, gasoline-powered hydraulic pumps and hoses that were heavier and less efficient.

Although NASA is considering using the cutter for emergencies in space, its principal purpose in developing it lay in leveraging the cost of the power unit by means of dual-use: by making the power unit a commercially viable product, NASA and the Department of Defense can bolster their own use of the technology. "These initiators are the same as those used in multi-stage rockets and in explosive bolts," explained Carl Ray, who is a technology programs operations manager and the TRP point of contact at NASA Headquarters. "NASA and the military use these initiators for different space-borne projects, as in separating the first and second stages on small rockets, which must be explosively separated."

Because of the small number of such rockets, the manufacturer made only a limited amount of the initiators, and so the cost was high. "But now with the advent of these initiators in the commercial market," Ray said, "you've expanded the production and the use of these items–the supply and demand goes up–so the price goes down."

Using only a nine-gram power unit, Lifeshear is compact–only 22 to 26 inches long–and lightweight, making it easily transportable to remote areas. The device takes only 30 seconds to set up. Hi-Shear makes two sizes. The LS200, a 1.5-inch cutter for shearing brake pedals, door hinges, seat sections, and steering wheel rims, weighs 8.5 pounds. LS100, a four-inch cutter for shearing the A, B, and C posts on cars, weighs 11.5 pounds. Lifeshear's portability and light weight, along with the tool's speed of operation, paid off in the treacherous collapsed-structure environment at the Oklahoma City site. The lighter weight also reduces the probability



The LS100 Lifeshear cutter (top) is a four-inch cutter, and the LS200 is a 1.5-inch cutter.

of lower back injuries to rescue workers using extractors.

As an industry leader in pyrotechnical actuated thrusters, explosive bolts, separation nuts, pin pullers, and cutters, Hi-Shear made a strong candidate for the TRP development project. It has supplied these items to nearly all of NASA's major deep space missions over the past 23 years. The company has demonstrated it intends to make a good return on the 1.6 million dollar investment in Lifeshear, half of which was supplied by TRP. By June 1995, Hi-Shear was finishing 100 units per month, with 1000 LS100s and 1000 LS200s in production. The effort supports seven machine shops and has created approximately 40 jobs in the Los Angeles area. Hi-Shear has deployed 60 distributors to market the tool to the nation's 40,000 fire departments. The cutter is listed below $2,000 (about 70 percent less than competing rescue equipment) to make it affordable for community rescue groups throughout the United States. The company also plans to expand the tool to other markets, such as military and civilian search and rescue operations, mining excavations, and cable- and wire-cutting operations. "We've shown it to sheriffs, highway patrol, ambulance groups, and there's a sizeable amount of interest from each one of them," said Hi-Shear Vice-President Walt Smith.

"We're working on a similar cutter for power companies," Smith added. "It's slightly more [advanced] than the unit we derived from the TRP program, but this device can cut a high-voltage power line. We're talking about 84 conductors of aluminum with 19 steel cords on the inside. It's very difficult to cut that even with a hydraulic unit."

The February 1994 TRP award to Hi-Shear represented the first TRP cooperative agreement with a contractor. Within six months, the company had Lifeshear in full production, making it the first contractor to complete a TRP design and development program. Announced by President Clinton in March 1993, the TRP program is part of a $1.7 billion Defense Reinvestment and Conversion Act passed by Congress. TRP projects are structured to reduce the cost of products made by the federal government while enhancing US competitiveness in the world market–which falls in line with NASA's mission to transfer technology to the private sector. The agency projects the TRP with Hi-Shear will generate millions in cost-savings for federal, state, and local rescue services.

For more information, contact Walt Smith, Hi-Shear Technology Corp., 24225 Garnier Street, Torrance, CA 90505-5323; Tel: (310) 784-2101; Fax: (310) 325-5354.

Rescue workers in Oklahoma City learn use of the Lifeshear cutter.

John F. Kennedy Space Center

In 1962, NASA began acquiring property for a space center to serve as a launch operations base for the Manned Lunar Landing program. Approximately 140,000 acres of state-owned land were purchased adjacent to Cape Canaveral, FL on Merritt Island, which became the home of John F. Kennedy Space Center (KSC).

KSC is the major NASA installation for preflight, launch, and landing operations and related programs supporting the space shuttle. Its activities include assembly, integration, and preflight preparation of the shuttle and its payloads; ground support equipment design and development; tracking and data acquisition; launch operations; recovery of the shuttle's solid rocket boosters; landing operations; refurbishment of the orbiter; flight operations support; and design, construction, operation, and maintenance of launch facilities.

Although these activities require extensive support facilities, only 5945 acres of KSC land have been developed or designated for NASA operations. Because Merritt Island is inhabited by endangered and potentially endangered wildlife, NASA entered into an agreement with the U.S. Fish and Wildlife Service to establish the Merritt Island National Wildlife Refuge within KSC boundaries. In addition, most of the Canaveral National Seashore falls within KSC. An Environmental Resources Document was created to forge an understanding of conditions and operations at the center–especially space shuttle launches–that may have an influence on the area's environment.

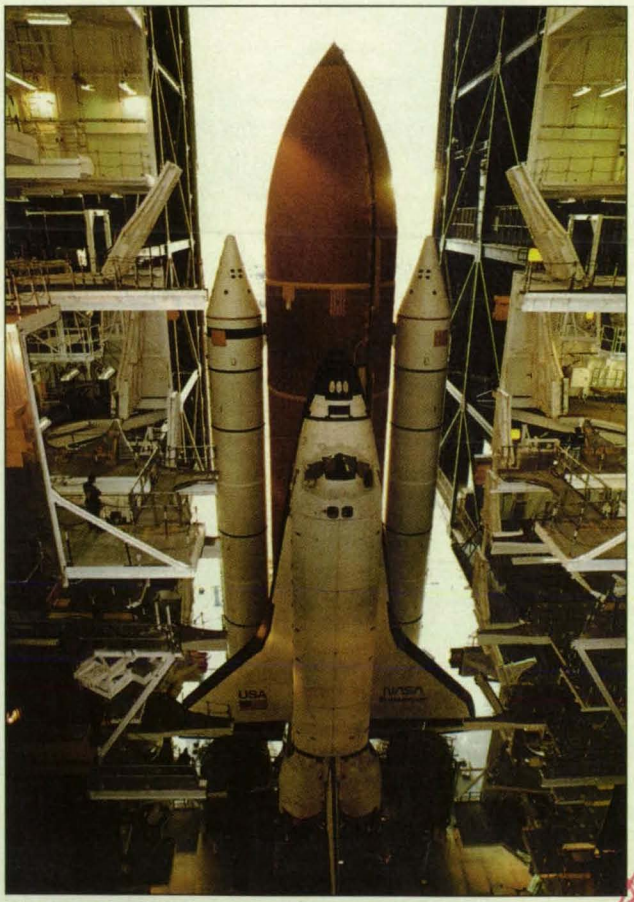
Getting the Message Out

KSC performs mainly applied–not basic–research, to support the space shuttle program. Bill Sheehan, chief of KSC's Technology Programs and Commercialization Office, explains that this operations focus brings the center more in alignment with industrial activity. The KSC research staff continually seeks to solve problems similar to those encountered in commercial applications.

"The fact that we do more applied research means that we probably are going to have a better opportunity to match up with commercial partners and transfer the technology we develop," Sheehan said. "When we develop a technology, we're advancing the state of the art in an area that has significant commercial applications. Our focus on new technology helps us improve the operations process."

In order to consolidate and expedite the transfer of that technology, in 1991 KSC became the first NASA center to combine its technology transfer and patent offices. A year-and-a-half later, technology development activities were brought in, combining Technology Transfer/Commercialization, Patent Counsel, Dual-Use, University Activity, Technology Inreach/Outreach, SBIR, and Advance Technology Development programs in one office. This provides single-point oversight of all technology development and research functions, reducing conflict between projects, eliminating duplication of research efforts, and resulting in a more efficient utilization of limited funds and personnel.

A unique aspect of technology transfer at KSC is the Dual-Use Program. Dual-use projects are research and development projects jointly pursued by NASA and industry where the results are planned to have both NASA and industry applications. Commercial partners and NASA co-fund dual-use projects; NASA also may provide funding for university or nonprofit organization projects.



The Space Shuttle Endeavour, weighing more than 19 million pounds with its support and transport hardware, is loaded aboard a crawler-transporter for its trip from the Vehicle Assembly Building to Launch Pad 39A. Once at the pad, the Endeavour and the mobile launch platform on which it was assembled and from which it will lift off, is deposited atop support columns to prepare for launch.

Florida's Technology Research and Development Authority (TRDA) joined with KSC in 1993 in a technology transfer partnership to "co-fund projects of mutual interest that have dual-use capability within the state," according to Sheehan. The agreement seeks to develop relationships with local economic development agencies as a means to reach businesses across Florida to commercialize new technologies, produce new products, and bring them to the marketplace. KSC joined with Marshall Space Flight Center and Stennis Space Center in the Southeast Regional Outreach Alliance to transfer benefits of NASA expertise to industries in the southeast U.S. The KSC program expands on this concept by utilizing Economic Development Councils in Florida as ambassadors of NASA technologies, providing an open and continuous information flow throughout the state.

In 1994, a dual-use project was instituted to develop the Universal Signal Conditioning amplifier (USCA), which can connect all types of sensors and transducers universally to current and proposed data acquisition systems. The USCA is needed

for KSC operations, but also has commercial applications. Originally designed by engineers from the center and I-NET, the KSC engineering support contractor, the TRDA assisted in co-funding the product with its partner, Loral Test and Information Systems.

The most important dual-use project currently underway is a joint effort with the Department of Energy to develop electronically active polymer coatings to protect metal from corrosion damage. Repainting metal structures on Shuttle launch pads that are exposed to multiple corrosive environments caused by the Sun, hydrochloric acid, and salt air, is extremely costly to NASA. If use of the coating is successful, the cost of NASA's investment could be recovered in a matter of years.

Through the Technology Transfer program, co-developers at KSC, Lockheed Space Operations, and NASA Ames received the largest Space Act Agreement award to date in 1993 for developing the Ground Processing Scheduling System, a software system that expedites scheduling of complex interactions of personnel, flight and ground hardware, and other resources involved in Space Shuttle Orbiter prelaunch processing operations. Through a copyright license, the technology was spun off by Red Pepper Software of San Mateo, CA, which introduced a commercialized version called ResponseAgent™ scheduling and planning software.

NASA On-Line

Over the past two years, KSC has developed the NASA-wide TechTracS database to manage and track new technologies reported to its Technology Programs and Commercialization Office. Most NASA centers feed technology information into the KSC central database, which automatically posts the data for access by NASA headquarters.

KSC also has its own World Wide Web (WWW) home page that provides a publicly-accessible source of information regarding the commercialization of KSC-developed technology. With this effort, KSC has led the way in "a unified NASA effort to make a presence on the World Wide Web," says James Aliberti, Manager of External Programs, Technology Transfer and Commercialization. Updated information on commercialization opportunities, patent and licensing information, and KSC facilities available for commercial use is available. The KSC home page can be accessed on the Internet at URL http://technology.ksc.nasa.gov.

For more information on commercial opportunities available through Kennedy Space Center, contact Bill Sheehan, Chief, Technology Programs and Commercialization Office, Mail Code DE-TPO, Kennedy Space Center, FL 32899; (407) 867-3017; E-mail: billsheehan @ksc.nasa.gov.

The Merritt Island National Wildlife Refuge within Kennedy Space Center is home to many species of endangered and potentially endangered animals and birds. The most famous residents are a family of Southern Bald Eagles that inhabit a nest just off KSC's main road. According to wildlife experts, eight to nine pair of bald eagles inhabit nests in KSC.

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Program for Simulating Dynamics of Aerospace Vehicles

A modular structure facilitates application to a variety of trajectory-analysis problems.

Lyndon B. Johnson Space Center, Houston, Texas

SORT (Simulation and Optimization of Rocket Trajectories) is a general-purpose three-degree-of-freedom with three axis static moment balance simulation of the flight dynamics of an arbitrary aerospace vehicle. It has been used extensively by the Missions Operation Directorate (MOD) of the Johnson Space Center (JSC) in the development of data-initialization loads for space shuttle missions as well as by JSC's Engineering Directorate for ascent and entry trajectory optimization of advanced launch vehicle and spacecraft concepts. Simulations created by this program have been compared rigorously to a number of other simulations throughout the years to certify its overall fidelity. SORT numerically models vehicle subsystems such as propulsion, guidance, steering, and static moment balance. It also contains numerous models for environmental effects including atmosphere, drag, gravity, and winds for a rotating oblate planet.

SORT has a well-designed modular structure that enables its application to a wide range of trajectory-analysis problems without need for minor modifications. The program includes iteration logic and discrete-event-simulation logic that are completely independent of the mathematical-model logic. The discrete-event-simulation logic provides the user with the capability to simulate a limitless number of flight profiles. With the generalized targeting and optimization capability, iterations can be performed upon input parameters to minimize a cost function subject to constraints. The input parameters, cost function, and constraints are specified by the user. The constraints can be of the equality or inequality type.

SORT contains a math model of aerodynamics that is completely generalized. It computes both longitudinal and lateral forces and moments. In addition to the fore-body coefficients, it computes the longitudinal base effect aerodynamic forces and moments. A simplified ballistic-coefficient model is also available for analysis of ballistic entry.

SORT includes a math model of propulsion that is highly generalized but simple to use. In this model, the vehicle can be represented as containing as many as 15 engines. Each engine can be specified as either liquid- or solid-fueled. A liquid-fueled engine can be further specified as being of either the monopropellant or the bipropellant type. The solid-fuel-engine submodel can adjust the thrust, rate of flow, and chamber-pressure tables to compensate for the effects of ambient temperature and changes in the rate of burning. The program provides numerous options for specifying angles of deflection of engines as well as a thrust-deformation model for simulations of higher fidelity. Each of the engines can be specified to be either throttleable or nonthrottleable. For static moment control, individual engines can be specified to be controllable or noncontrollable. The degrees of controllability of individual engines can also be specified via gain tables.

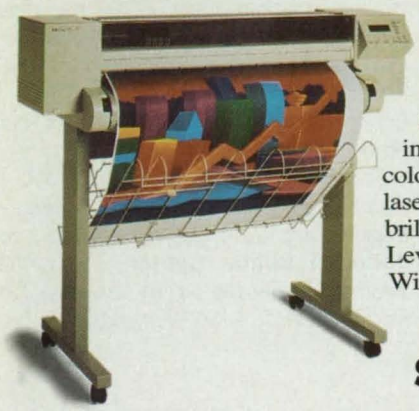
SORT also includes a mass-properties math model; this is a composite model that enables the user to represent the vehicle as a system that contains as many as fifteen mass subsystems. Each mass subsystem can be specified to be either inert mass or propellant. For higher fidelity, a center-of-mass history is attributed to each mass subsystem. The composite center of mass of the vehicle is computed by use of the parallel-axis theorem. The mass history of the vehicle is computed by integrating the propellant-depletion history via one of the three available numerical-integration schemes. In addition to expressing vehicle weights directly, SORT contains weight-estimation algorithms for use in analyses directed toward sizing two-stage launch vehicles.

SORT contains four stored atmosphere models as well as two generalized table-lookup models. The first generalized table-lookup algorithm provides the capability to input speed-of-sound data as well as to compute speed of sound by use of the perfect-gas law. The second table-lookup algorithm provides the capability to gain access to data from a binary direct access file.

The parameter optimization logic of SORT is unique in that it provides the flexibility to solve difficult trajectory-design problems via a multilevel approach. The program provides the capability to break a trajectory design into as many as seven levels. Each of the levels can be nested either sequentially or recursively. A library of six iteration-and-optimization techniques is available to be used in any optimization level. These algorithms include the Variable-Metric Algorithm for Constrained Optimization (VMACO), the Multiple-Gradient Optimization Algorithm (MGOA), Newton-Raphson technique, a quadratic-curve-fit algorithm, a secant-method algorithm, and a carpet-plotting algorithm. In addition, a SORT interface to NPSOL (Nonlinear Programming algorithm from Stanford University's Systems Optimization Laboratory) is also provided. Any feasible flight dynamics math model input parameter can be used as a control parameter and any feasible flight dynamics math model output parameter can be used as a constraint or optimization parameter.

The input and output features of SORT are designed to maximize flexibility and ease of use. Highlights include comprehensive input error diagnostics as well as complete control by the user over the output from the program. For ease of use, SORT provides output in either landscape or portrait format. To aid the interpretation of the results of iterations, modular tabular histories of iterations as well as abbreviated summaries of trajectories are provided. Trajectory ephemeris data are provided in both ASCII and binary formats. Two binary ephemeris output options are provided to enable use with various plotting programs.

SORT was written using ANSI FORTRAN 77 and runs on DEC VAX-series computers under VMS, CRAY X-MP- and Y-MP-series computers under UNI-



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COS, and HP9000-series 700/800 computers running HP-UX v9.01 or higher. With minimal modifications, SORT can be ported to other computers and operating systems. The program requires 2MB of random-access memory for execution and approximately 15MB of disk space for installation. It should be noted that the 15MB of disk space includes storage for sample input and output data. For full implementation of the SORT program, the user needs to obtain the Nonlinear Programming algorithm, NPSOL, developed at Stanford University's Systems Optimization Laboratory [Stanford Business Software, Inc., Stanford, CA, Dr. Mukund Thapa, (415) 962-8719].

The VAX/VMS, CRAY, and HP9000 distributions of SORT contain identical code, including the machine-independent code and the machine-dependent code for all three types of computers; only the storage formats and distribution media differ. The standard distribution medium for the DEC VAX/VMS version of SORT is a 1,600-bit/in. (≈630-bit/cm), 9-track magnetic tape in DEC VAX BACKUP format. This version is also available on a TK50 tape cartridge in DEC VAX BACKUP format. The standard medium for distribution of the CRAY version of SORT is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. The standard medium for distribution of the HP9000 version of SORT is a 4-mm DAT tape in UNIX tar format. For the HP9000 and CRAY versions, alternate distribution media and formats are available upon request. SORT has been developed over a period of years, version 7.0 having been released in 1993. For the next release of SORT, a Graphical User Interface (GUI) is currently under development.

This program was written by M. J. Berning and K. D. Sagis of Lockheed Engineering and Sciences Co. for **Johnson Space Center**. *For further information,* ***write in 61*** *on the TSP Request Card. MSC-22496/97/98*

Software for Real-Time Simulation of Subsystems

This program provides a practical method of understanding small systems integrated into larger ones.

Lyndon B. Johnson Space Center, Houston, Texas

The Real-Time Software Simulation of a Small Imbedded System (SSO) computer program was developed for use in simulating any one of a number of systems and subsystems of the space shuttle *Columbia*. These systems and subsystems include the system control module (SCM), its ground support equipment and test assembly (GSE/TA), and the support system for orbiter experiments (OEX). The support system consists of the SCM, the orbiter experiments tape recorder, and the orbiter experiments pulse-code-modulation (PCM) data system. Some of the apparatuses that implement the experiments are the Shuttle Entry Air Data System, the Shuttle Upper Atmosphere Mass Spectrometer, the Shuttle Infrared Leeside Temperature Sensing System, the Aerodynamic Coefficient Identification Package, and the High Resolution Accelerometer Package.

SSO includes subprograms called the "GSE/TA simulator" and the "SCM simulator." The GSE/TA simulator determines the integrity of the SCM in a pre- and in a post- flight configuration. With the help of SSO, the time spent in cross training will be significantly less than that spent in cross training by the present method. SSO also provides a practical method of understanding small systems imbedded in an integrated environment like that of the space shuttle *Columbia* without having to turn on the real GSE/TA and flight hardware.

The SCM and GSE/TA simulators provide an extremely flexible means of controlling the OEX tape recorder, the PCM system, and the experiment. These simulators receive and send commands from simulated ground stations at Kennedy Space Center, Edwards Air Force Base, and the Johnson Space Center via a simulated multiplexer/demultiplexer computer. These commands provide on/off discrete outputs to control the tape recorder and as many as 31 other functions of the experimental apparatuses and the data system.

SSO also provides for simulation of an analog subsystem in which one can switch any one of 32 simulated analog inputs to any one of 28 tape-recorder tracks and 4 simulated ground-support data channels. All of the traditional tape-recorder controls are also provided, with the addition of several functions, including track sequence, mark, go to mark, snapshot, and log. SSO also provides the capability to store sequences or commands for later execution. The commands can be sent from the simulated ground station or stored in a simulated program memory before flight. The execution delays for the valid commands can be modified during all simulated missions, enabling adaptation to contingencies.

The most complex parts of SSO involve the real-time operations. These operations include the command input/output (I/O), the implementation of the internal clock, and control of the OEX tape recorder, with commands and arguments to be received asynchronously on an interrupt basis. The timing between command words can vary between milliseconds and hours. Consequently, all operations are performed with interrupts enabled because disabling interrupts can cause a command to be missed entirely.

The ultimate real-time function of SSO is the control of the OEX tape recorder. Apart from the expected speed and direction settings, SSO provides a number of high-level functions that enable the recorder to be positioned automatically at the beginning or end of the tape or at a position previously set by a special "mark" command. SSO maintains a table, by means of which a "mark" number is issued at the end of a recording sequence. The simulator places a 9,000-ft (≈2,700-m) tape within 7 in. (≈18 cm) of the marked position at a later time. SSO provides for reversal of the direction of travel of the tape, redirecting data from sources to unused tracks, and restarting a recording sequence automatically when either end of the tape is reached. The GSE/TA simulator provides 17 self-tests that determine the health of the SCM simulator while using a switch-setting function on the control page (an interactive display) of the GSE/TA simulator. All control pages were designed to be user-friendly.

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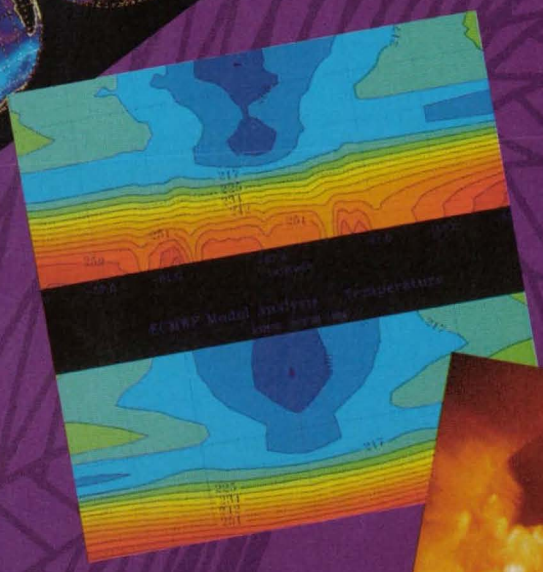

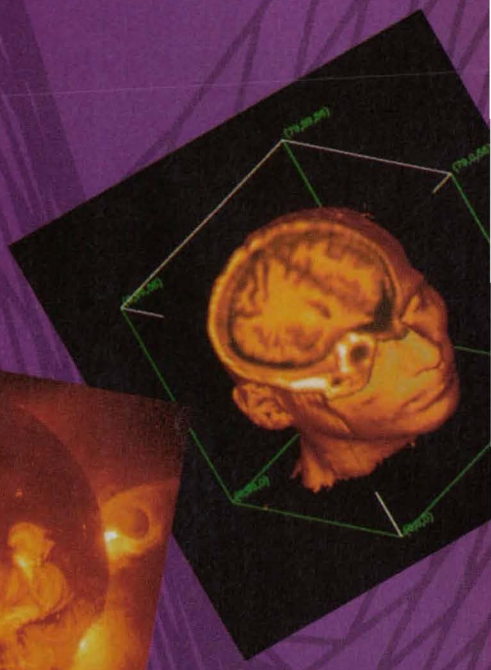

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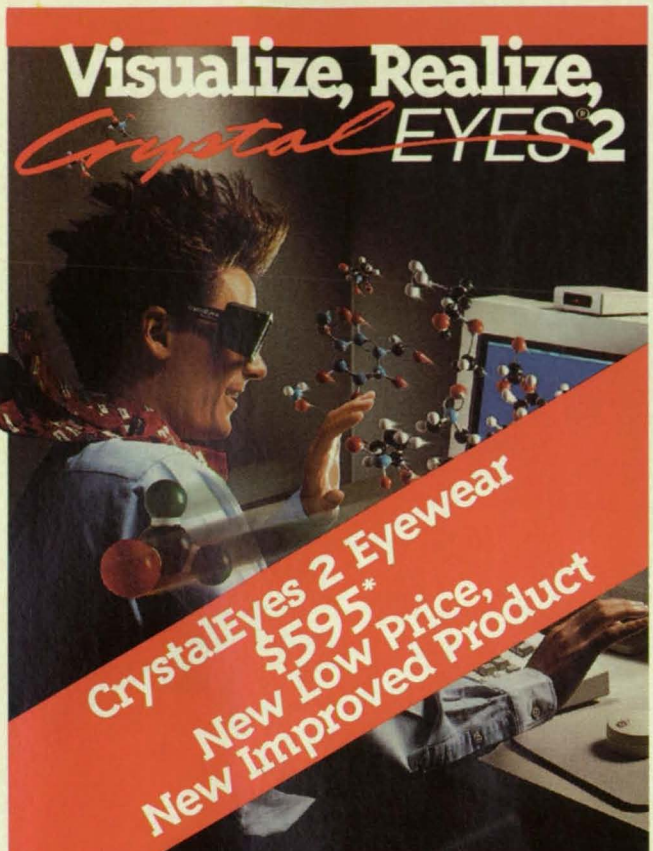

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SSO consists of four subprograms written in C language for use on IBM PC-series and compatible computers running MS-DOS. It requires at least 640K of random-access memory and MS-DOS 3.1 or higher. Because of the complexity of SSO, a VGA graphics display is highly recommended. The source code requires the MicroSoft C v6.0 compiler; however, a sample MS-DOS executable code is provided. The standard distribution medium for this program is a set of three 5.25-in. (13.335-cm), 360K MS-DOS format diskettes. The contents of the diskettes are compressed by use of the PKWARE archiving software tools. The utility software to unarchive the files, PKUNZIP.EXE, is included. This program was developed in 1990.

This program was written by Dwight A. Favors, Dan Devoss, and Michael Cheatham of Lockheed Engineering and Sciences Co. for **Johnson Space Center**. *For further information,* ***write in 202*** *on the TSP Request Card. MSC-22250*

Graphical Displays Assist in Analysis of Failures

Digraphs or engineering schematics can be used.

Lyndon B. Johnson Space Center, Houston, Texas

The Failure Environment Analysis Tool (FEAT) computer program enables people to see and better understand the effects of failures in a system. FEAT uses digraph models to determine what will happen to a system if a set of failure events occurs and to identify the possible causes of a selected set of failures. The user can select failures from graphical displays in either engineering schematic form or digraph model form, and the effects or potential causes of the failures will be highlighted in color on the same schematic or model graph.

As a design software tool, FEAT helps design reviewers understand exactly what redundancies have been built into a system and where it is necessary to protect or design out weak parts. A properly developed digraph can reflect how a system functionally degrades as failures accumulate. FEAT can also be used in operations to help identify causes of failures after they occur. Finally, FEAT is valuable both in conceptual development and as a training aid, inasmuch as digraphs can identify weaknesses in scenarios as well as hardware.

Digraph models for use with FEAT are generally built with the help of the Digraph Editor — a Macintosh-based application program that is distributed with FEAT. The Digraph Editor was developed specifically with the needs of FEAT users in mind and offers several timesaving features. It includes an icon software toolbox of components needed in a digraph model and a menu of functions for manipulating these components. It also offers the FEAT user a convenient way to attach a formatted textual description to each digraph node. These node descriptions are necessary to enable FEAT to recognize nodes and propagate failures within a digraph.

The FEAT user stores node descriptions in modeling tables by use of any word-processing or spreadsheet software package capable of saving data to ASCII text files. From within the Digraph Editor, the user can then interactively attach a properly formatted textual description to each node in a digraph. Once descriptions are attached to them, a selected set of nodes can be saved as a library file that represents a generic digraph structure for a class of components. A feature called

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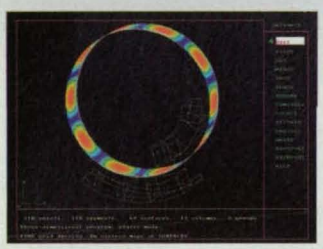

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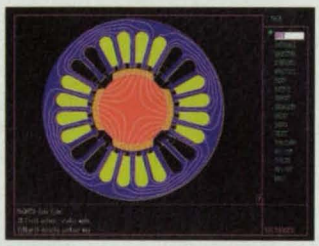

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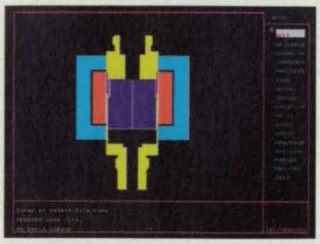

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"Generate Model" can then use library files to generate digraphs for every component listed in the modeling tables, and these individual digraph files can be used in a variety of ways to speed generation of complete digraph models.

FEAT contains a preprocessor subprogram that performs transitive closure on the digraph. This subprogram implements a multistep algorithm that builds a series of phantom bridges, or gates, that enable accurate bidirectional processing of digraphs. In the cases of extremely large models, this preprocessing can consume substantial time, but once preprocessing is complete, queries can be answered and displayed within seconds. A UNIX X-Windows port of version 3.5 of FEAT, called "XFEAT," is also available, and can speed the processing of digraph models. These models are created on a Macintosh computer. FEAT v3.6, which is available for the Macintosh only, provides some report-generation capabilities that are not available in XFEAT.

For very large integrated systems, FEAT can reduce the costs of evaluation of designs, training, and capturing knowledge. Because it is possible to load multiple digraphs and schematics into FEAT, modelers can use FEAT to organize models of systems into smaller, more focused digraphs. Typically, each digraph file represents only a portion of a larger failure scenario. FEAT combines these files and digraphs to form a continuous mathematical model of the failure logic of a system. Inasmuch as multiple digraphs can be cumbersome to use, FEAT ties propagation results to schematic drawings produced by use of MacDraw II (version 1.1v2 or later) or MacDraw Pro. This makes it easier to identify single- and double-point failures that may have to cross several system boundaries and multiple engineering disciplines before creating a hazardous condition.

FEAT v3.6 for the Macintosh computer is written in C language by use of Macintosh Programmer's Workshop C v3.2. It requires at least a Mac II-series computer running System 7 or System 6.0.8 and 32-Bit QuickDraw. It also requires a math coprocessor or coprocessor emulator and a color monitor (or one with 256-gray-scale capability). A minimum of 4MB of free random-access memory (RAM) is highly recommended. The UNIX version of FEAT includes both FEAT v3.6 for the Macintosh and XFEAT. XFEAT is written in C language for Sun-series workstations running SunOS, SGI workstations running IRIX, DECstations running ULTRIX, and Intergraph workstations running CLIX version 6. It requires the MIT X Window System, Version 11, Revision 4, with OSF/Motif 1.1.3, and 16MB of RAM.

The standard medium for distribution of FEAT 3.6 (Macintosh version) is a set of three 3.5-in. (8.89-cm) Macintosh-format diskettes. The standard distribution package for the UNIX version includes FEAT in three FEAT 3.6 Macintosh diskettes, plus XFEAT in a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (QIC-24) in UNIX tar format. Alternate distribution media and formats for XFEAT are available upon request. FEAT has been under development since 1990. Both FEAT v3.6 for the Macintosh and XFEAT v3.5 were released in 1993.

This program was written by Ginger Pack, David Wadsworth, and Reza Razavipour of **Johnson Space Center.** *For further information,* ***write in 52*** *on the TSP Request Card. MSC-22446*

Program Aids Visualization of Data

This program eliminates the need for custom graphical-display software for application programs.

Lewis Research Center, Cleveland, Ohio

The Living Color Frame System (LCFS) computer program was developed to solve some of the problems that arise in connection with the generation of real-time graphical displays of numerical data and of the statuses of systems. The need for a program like LCFS arises because computer graphics are often applied for better understanding and interpretation of data under observation and these graphics become more complicated when animation is required during run time, as in many typical modern artificial-intelligence and expert systems.

LCFS includes a software tool for the generation and management of graphics, provides a user-friendly graphical interface with mouse-driven controls, and provides extensive on-line instructions. Regarded as a system, LCFS consists of a number of modules that can be used to create graphics screens (frames), receive and record data from a hardware or software source, and update screen information to reflect changes in incoming data. The modules also make it possible for the graphics screens to be logically linked (through frame objects), and then dynamically recalled (unique object-oriented zooming technique) for display in real time by use of mouse commands. Run-time software for the inclusion of custom video and sound effects on these frames is also provided (complete demonstration programs). Support for such functions as display of monitored data, manipulation of graphical images, and sounding of the computer buzzer is included.

In some applications, the generated graphical frames can be visual aids for managing systems. LCFS is suitable for integration into a wide range of real-time application programs in which graphical displays are needed. For example, for purposes of monitoring, diagnosis, and/or control, circuit or system diagrams can be brought to life by use of designated video colors and intensities to symbolize the status (real-time feedback from sensors, calculated values, etc.) of systems, subsystems, and components of hardware. LCFS eliminates the need for custom programming of computer graphics, enabling software developers to focus on the functionalities of their application programs.

LCFS is written in Turbo C++ for IBM PC-series and compatible computers running MS-DOS v3.3 or later. The program requires at least 88K of random-access memory, a color display (CGA, EGA, VGA), and a two-button mouse. The distribution medium includes an electronic copy of the documentation in WordPerfect format, a sample executable code, and a demonstration file. The standard medium for distribution of LCFS is a 3.5-in. (8.89-cm), 1.44MB, MS-DOS-format diskette. LCFS was developed in 1993 and is a copyrighted work with all copyright vested in NASA.

This program was written by L. V. Truong of **Lewis Research Center.** *For further information,* ***write in 26*** *on the TSP Request Card. LEW-15917*

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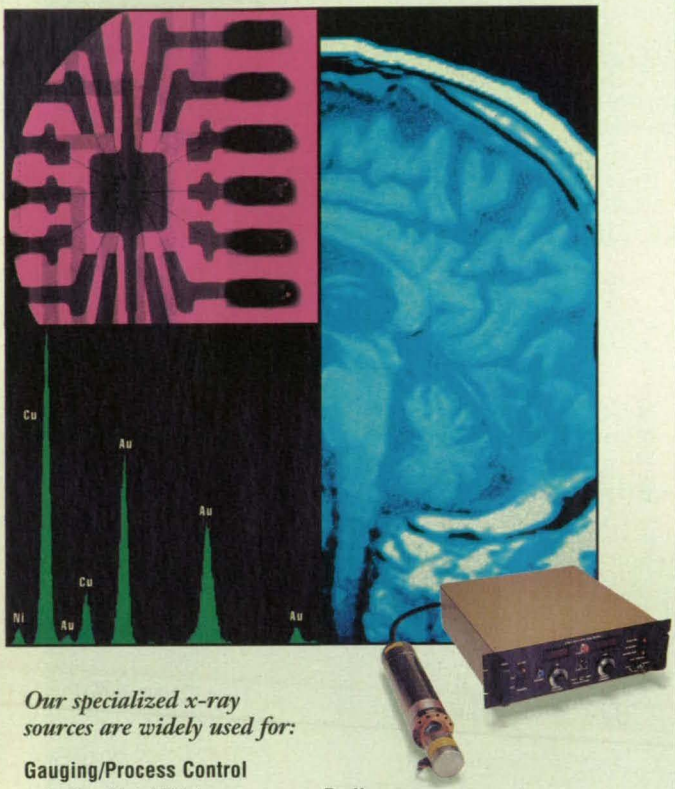

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Software Aids in Graphical Depiction of Flow Data

This program generates contour, vector, shaded, *x-y*, and carpet plots.

Lewis Research Center, Cleveland, Ohio

The Interactive Data Display System (IDDS) computer program is a graphical-display program designed to assist in the visualization of three-dimensional flow in turbomachinery. Grid and simulation data files in PLOT3D format are required for input. This program is able to unwrap the volumetric data cone associated with a centrifugal compressor and display results in easy-to-understand two- or three-dimensional plots. IDDS provides the majority of the visualization and analysis capability for the Integrated Computational Fluid Dynamics and Experiment (ICE) system. In the ICE computing environment, IDDS can be invoked from any subsystem, or it can be used as a stand-alone package of display software.

IDDS offers five different plotting styles: contour, vector, shaded, *x-y*, and carpet. All of these styles are available for both two-dimensional and three-dimensional data. For three-dimensional plotting, IDDS automatically combines the *i, j, k* indices and predetermines views. These views are cross-channel, blade-to-blade, and meridional. The cross-channel view is formed by combining all *i* and *j* indices, and is intended to show secondary flow characteristics. A blade-to-blade view is developed by combining all *i* and *k* indices, and is intended to show streamwise flow characteristics on a plane parallel to the hub from inlet to outlet. The meridional view is constructed by combining all *j* and *k* indices. This view is also intended to show streamwise characteristics, but in a plane parallel to a blade surface from inlet to outlet.

IDDS enables the user to select up to four windows and plots to be displayed on the computer video screen. A unique file can be associated with each window for comparison of plotted data. Options for customization of plots include: the variable for display, orientations of slices through the data, type of plot, numerical and color ranges for color bars, contour levels, and vector levels.

Geometric coordinates are taken directly from a grid file specified by the user. IDDS enables the user to display the geometry, orient it as desired, and then overlay the desired plot on top of the geometry. After selection of the desired plot(s) and geometry, the display is built. The user has the option to display the grid, the plot, and/or the geometry individually or in any combination. After the picture is rendered, the user can rotate, translate, or zoom on the display.

IDDS is written in C language for Silicon Graphics IRIS- and Indigo-series workstations running IRIX. IDDS requires a minimum of 16MB of random-access memory and a display capable of 24-bit Z-buffering. A sample executable code is included. The input file format used by IDDS is that of PLOT3D (COSMIC item ARC-12782). The creation of these input files is fully detailed in the documentation. The standard medium for distribution of IDDS is a 0.25-in. (6.35-mm) IRIX-compatible streaming-magnetic-tape cartridge in UNIX tar format. IDDS was developed in 1993.

This work program was written by J. D. Stegeman of **Lewis Research Center.** *For further information,* ***write in 90*** *on the TSP Request Card. LEW-15885*

Electronic Components and Circuits

Tilting a Small Reflector for Vernier Pointing of a Large Antenna

It is easier to tilt the small mirror than to tilt the massive antenna structure.

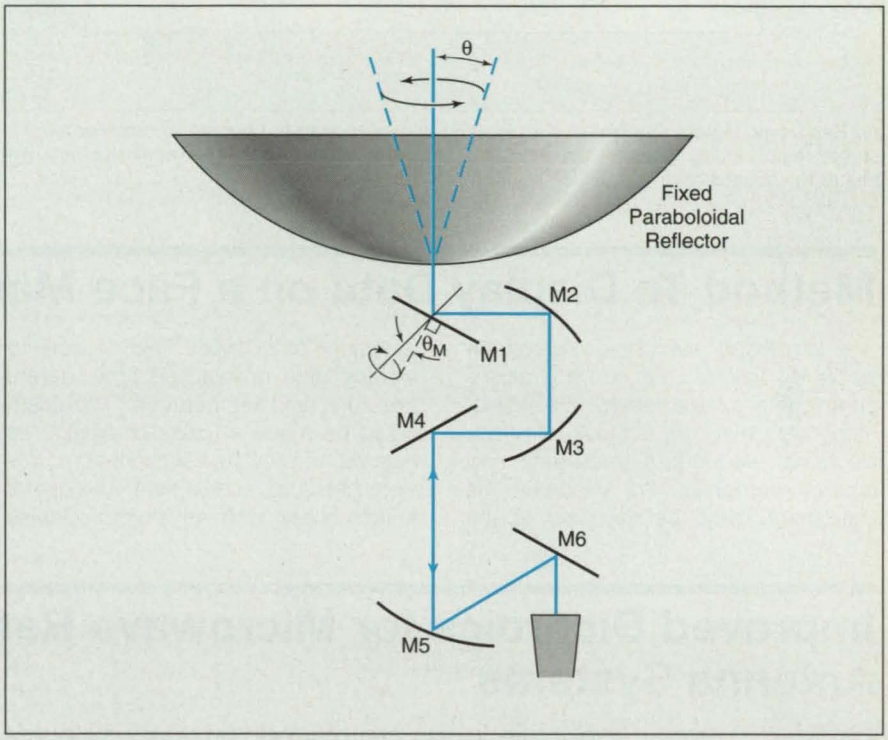
NASA's Jet Propulsion Laboratory, Pasadena, California

A simple vernier pointing technique has been devised to facilitate scanning the beam pointing of a large paraboloidal reflector so that the line of sight of the antenna sweeps out a narrow cone about a fixed axis (conical scan, also known as "conscan" in the art). In this technique, the scan is effected by one of the relatively small beam-waveguide reflectors or mirrors (see figure) that couple signals between the antenna and its distant transmitting and/or receiving electronic circuits.

In the original application, the antenna is one of the Deep Space Network (DSN) antennas, with a paraboloidal reflector 34 m in diameter, operating at a frequency of 32 GHz. The required half-cone angle for scanning at 0.1 dB below the beam peak gain is 0.0016°. It would be very difficult to achieve such a fine conical scan by tilting the entire massive antenna structure as in previous DSN conscan systems. However, it is relatively easy to tilt one of the far smaller beam-waveguide mirrors.

Any of the beam-waveguide mirrors could be used for this purpose. The one chosen in the original application is located at the elevation axis of the antenna. A geometric analysis shows that the required 0.0016° conical scan of the beam peak of the antenna can be achieved by a 0.0375° conical scan of this mirror, labeled "M1" in the figure.

Note that this scan is much larger than is the required scan of the beam peak; this indicates that the aim of the antenna is relatively insensitive to an error in the tilt of this mirror, and consequently the scanning mechanism can be less precise than that needed for equivalent scanning of the entire antenna. The loss of beam peak gain directly attributable to the conical scan of this mirror is only about 0.01 dB.



One of the Flat Mirrors Is Tilted through a small angle, θ_M, to obtain an even smaller beam-peak deviation, θ, of the line of sight of the antenna. Although M1 is tilted in this example, any of the other mirrors M2 through M6 could be tilted instead.

This work was done by Watt Veruttipong and Dan A. Bathker of Caltech for ***NASA's Jet Propulsion Laboratory****. For further information,* ***write in 14*** *on the TSP Request Card. NPO-19366*

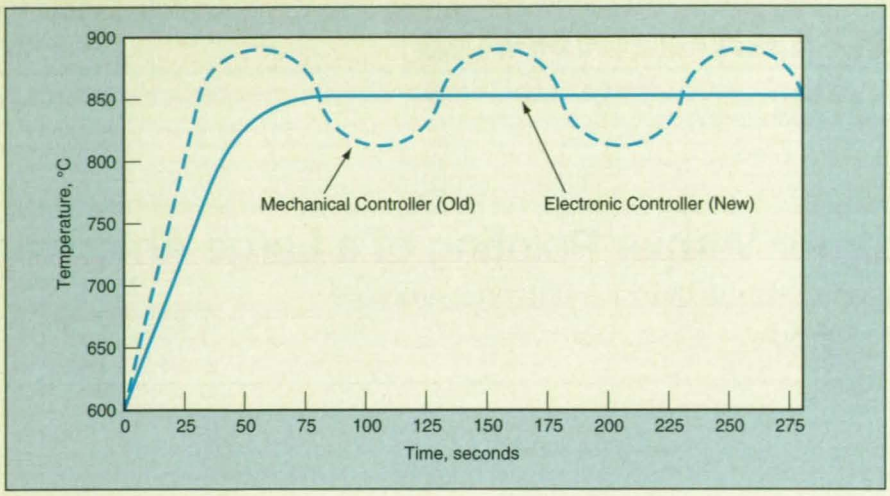
Improved Controllers for Heaters in Toxic-Gas Combustors

Solid-state power controllers would overcome deficiencies of mechanical power controllers.

NASA's Jet Propulsion Laboratory, Pasadena, California

Commercial electronic proportional controllers have been installed in place of mechanical power controllers for electric heaters in toxic-gas combustors at NASA's Jet Propulsion Laboratory. A mechanical controller of the type in question is designed to maintain the temperature of a heater at a preset value by turning power fully on or fully off when the temperature falls below or rises above that value, respectively. This results in an oscillating on/off mode of operation characterized by excessive consumption of energy and by frequent failures caused by (1) overpowering of the heater, (2) surging of power to the heater, (3) excessive temperature overshoot, (4) excessive on/off cycling of the temperature controller, (5) excessive expansion and contraction of the heater element, and (6) thermal shock to the heater element.

In contrast, an electronic proportional controller supplies only the power needed to maintain the temperature of the heater nearly constant at the preset value, eliminating the large cyclic stresses of on/off operation (see figure). The result is increased efficiency and reduction of the incidence of failures. The operation of the combustor is not otherwise affected.



An **Electronic Power Controller** supplies just enough power to keep an electric heater at a preset temperature, whereas the older mechanical controller that it replaces subjects the heater to stressful on/off oscillation about the preset temperature.

This work was done by James Wishard, James Lamb, Edward Fortier, Hugo Velasquez, and Doug Waltman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 6*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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4800 Oak Grove Drive
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Refer to NPO-19281, volume and number of this NASA Tech Briefs *issue, and the page number.*

Method To Display Data on a Face Mask

A proposed electronic instrument would display information on a diver's or firefighter's face mask. The instrument would include a mask, a prism, electronic readouts, a transceiver and control electronics. For example, the instrument could be mounted at the periphery of a diver's field of view to provide data on elapsed time, depth, pressure, and temperature. The prism could be made of glass or plastic, as needed, to provide resistance to corrosion, pressure, and/or heat. The use of a face mask with an integral display would provide greater safety and convenience to the user.

This work was done by Kevin-Duron Moore, P. E. of **Johnson Space Center**. *For further information,* ***write in 22*** *on the TSP Request Card.*

MSC-22510

Improved Dichroics for Microwave Reflector Antenna Systems

Gridded square conductive loops are placed between dielectric slabs.

NASA's Jet Propulsion Laboratory, Pasadena, California

A panel that contains an array of grid and square conductive loops as array elements is designed to reflect most of the incident electromagnetic radiation in the K_u band (13.5 to 15.5 GHz) and to pass that in the X band (7 to 9 GHz). Furthermore, it is designed to exhibit this dichroic property at angles of incidence up to 40° in transverse electric, transverse magnetic, or circular polarization.

The concept of the gridded-square-loop dichroic array is related to that of the double-loop dichroic arrays described in "Frequency-Selective Microwave Reflectors" (NPO-18701), *NASA Tech Briefs*, Vol. 18, No. 1 (January 1994), page 32. Figure 1 shows part of an array of conductive loops, which is fabricated by etching the gridded-square-loop pattern on a polyimide substrate 0.003 in. (0.08 mm) thick and depositing copper on the pattern. Such an array on a substrate, unaccompanied by other components, exhibits the

(continued on page 38)

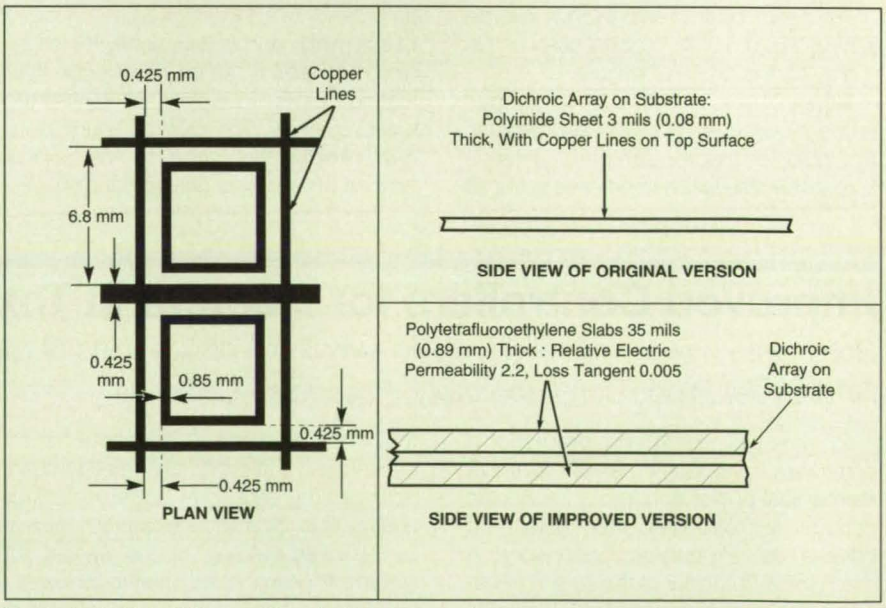
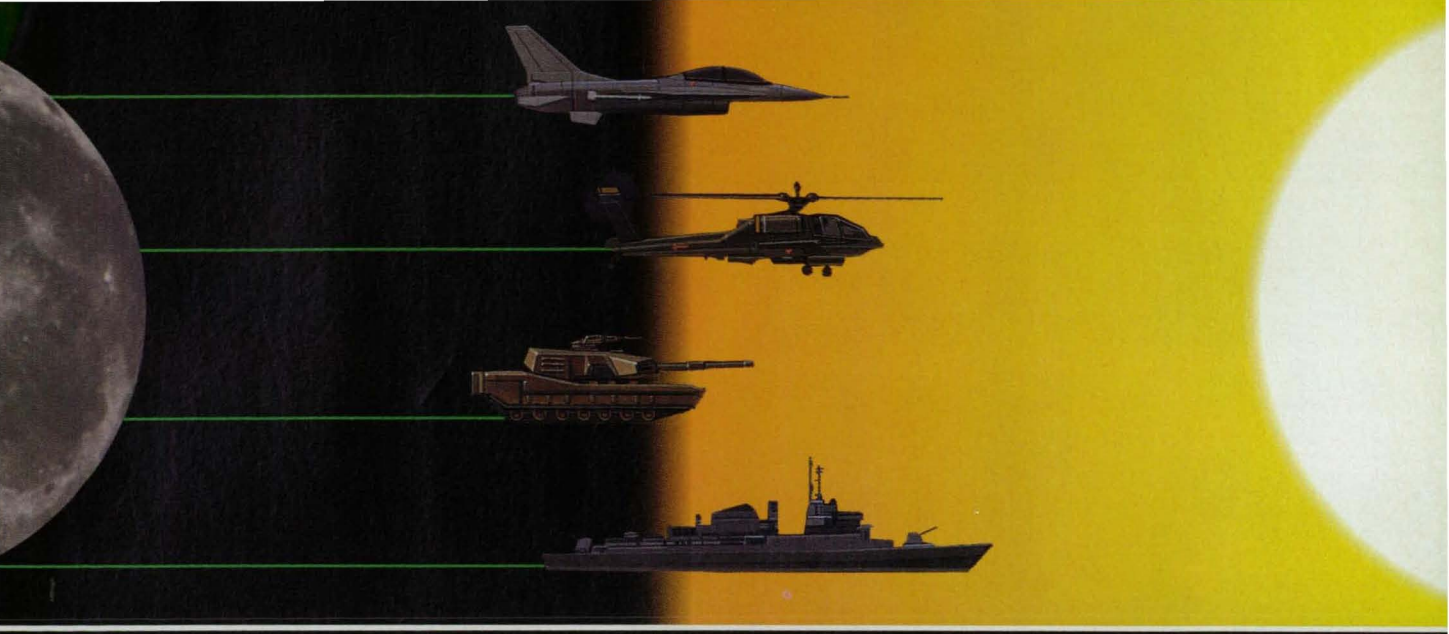


Figure 1. **Grid and Square Conductive Loops** of copper are deposited on a polyimide substrate to form a dichroic array of microwave antenna elements. The original version consists of such a substrate and array alone. The improved version consists of the substrate and array sandwiched between dielectric slabs.



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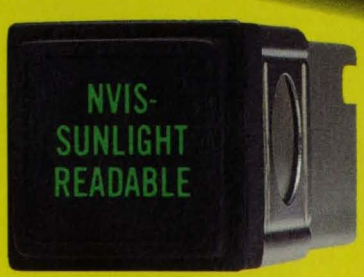

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(continued from page 34)

desired dichroic property near normal incidence, but it exhibits unacceptably high losses at an angle of incidence of 40°. These losses are related to the fact that the resonant frequency of the array shifts by about 1.5 GHz as the angle of incidence increases from 0° to 40°.

The improved dichroic reflector is constructed by embedding a substrate that bears an array between two low-loss dielectric slabs and bonding the layers together with low-loss adhesives. These slabs act as matching layers, reducing the dependence of the resonant frequency on the angle of incidence. Figure 2 shows computed transmission performances of the previous and improved dichroics, indicating that the shift in resonant frequency at 40° incidence on the improved reflector is less than 1 GHz.

This work was done by Te-Kao Wu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 133*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL; (818) 354-5179. Refer to NPO-18664.

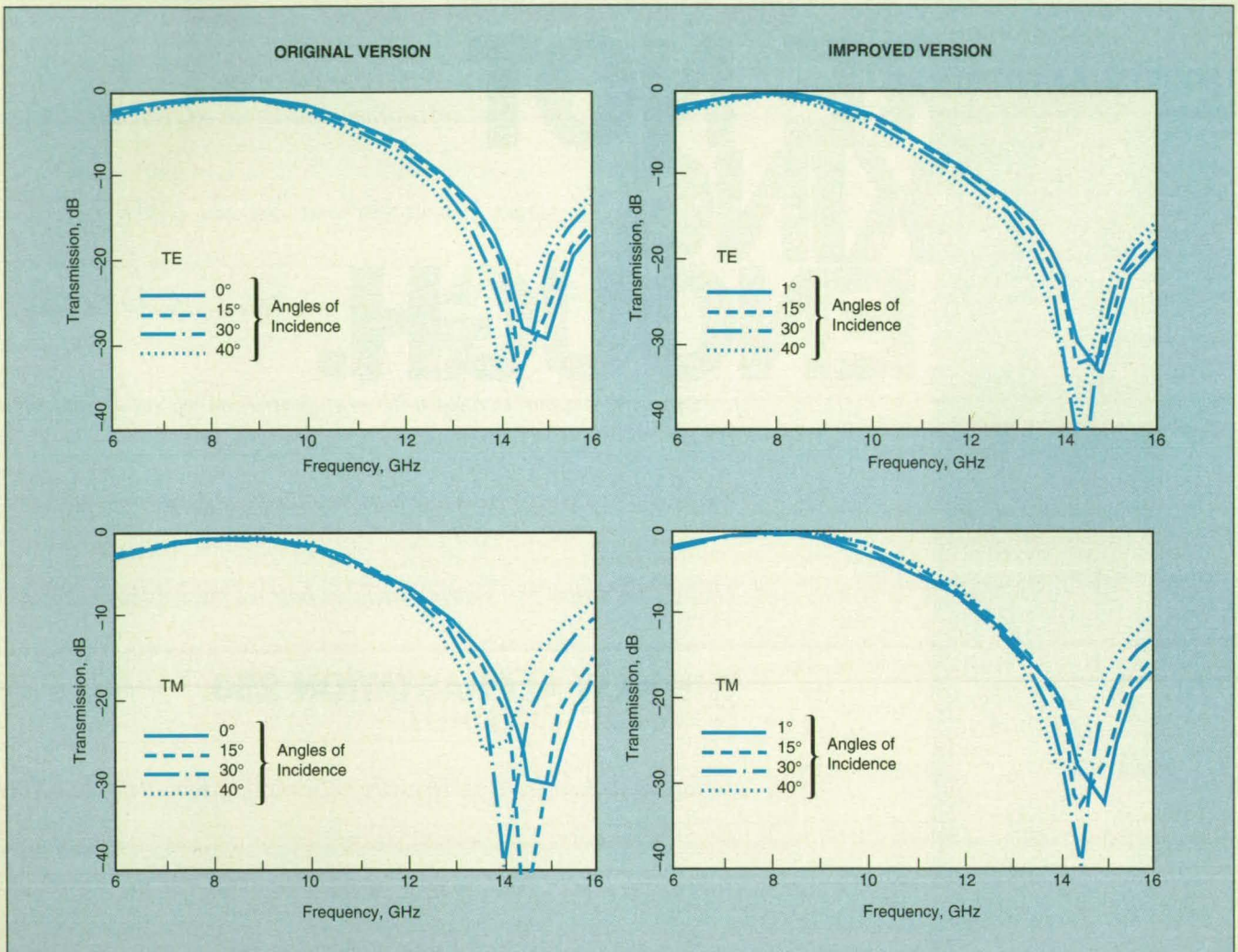

Figure 2. **Transmission Characteristics** of the original and improved dichroic reflectors were calculated. The improved version exhibits a smaller shift of resonant frequency with angle of incidence.

Making Curved Frequency-Selective Microwave Reflectors

Conductive grid elements are formed photolithographically on the curved reflector surfaces.

NASA's Jet Propulsion Laboratory, Pasadena, California

Prototype curved lightweight dichroic microwave reflectors that are designed to be highly reflective in the X and K_a frequency bands and highly transmissive in the K_u and S bands were being fabricated at the time the information was submitted for this article. These reflectors are intended for use as subreflectors of a main paraboloidal antenna reflector to enable simultaneous operation in both a prime-focus configuration in the K_u and S bands and a Cassegrain configuration in the X and K_a bands.

The basic concepts of these reflectors were described in "Frequency-Selective Microwave Reflectors" (NPO-18701), *NASA Tech Briefs*, Vol. 18, No. 1 (January 1994), page 32. Closely related reflectors were described in "Double-Square-Loop Dichroic Microwave Reflector" (NPO-18676), Vol. 18, No. 3 (March 1994), page 38; "Triband Circular-Loop Dichroic Microwave Reflector" (NPO-18714), Vol. 18, No. 3

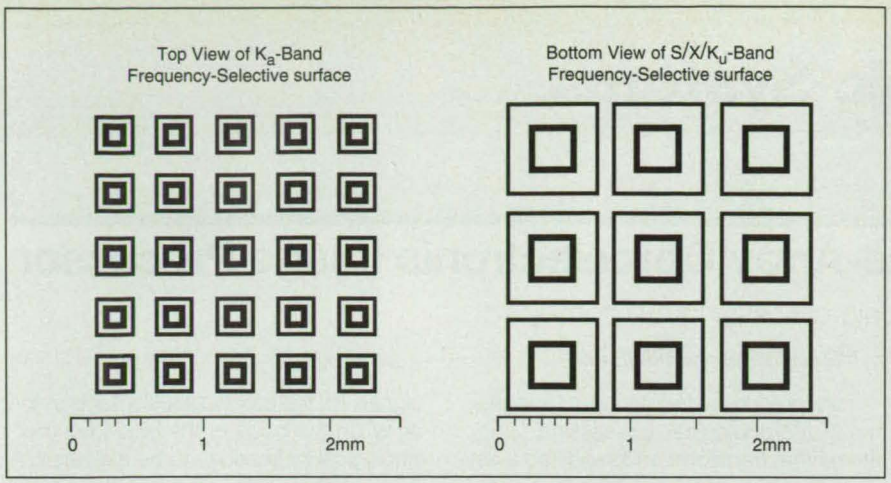

Figure 1. These **Periodic Arrays of Double Square Loops** of metal on aromatic polyamid/epoxy face sheets act as the frequency-selective surfaces in the add-on design.

(March 1994), page 41; and "Improved Dichroic Microwave Reflector" (NPO-18664), Vol.19, No. 8, (August 1995), page 34.

The design selected for fabrication of the curved dichroic reflectors is the one called "add-on" in the first-mentioned prior article. To recapitulate: A reflector of this type is constructed as a unitary sandwich panel with a rigid dielectric core and frequency-selective front and back surfaces, which are implemented as periodic arrays of double-square-loop electrically conductive patches on thin dielectric sheets. The front surface is highly reflective in the K_a band and highly transmissive in the S, X, and K_u bands; the back surface is highly reflective in the X band and highly transmissive in the S and K_u bands (see Figure 1). (In another design called "integrated," only one dielectric face sheet supports an array of double-loop conductive elements that satisfies the basic frequency-selective transmission and reflection requirement. The add-on design was selected over the integrated design on the basis of manufacturing and mechanical considerations.)

The prototype dichroic reflectors that were built and tested previously were flat approximations of the required curved ones. Figure 2 is a flow diagram of the process for fabrication of a curved one with a dielectric honeycomb core. The unique aspect of this process is that the conductive loop elements are formed photolithographically on the face sheets by direct laser imaging.

This work was done by Gregory S. Hickey and Te-Kao Wu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 137*** *on the TSP Request Card. NPO-18755*

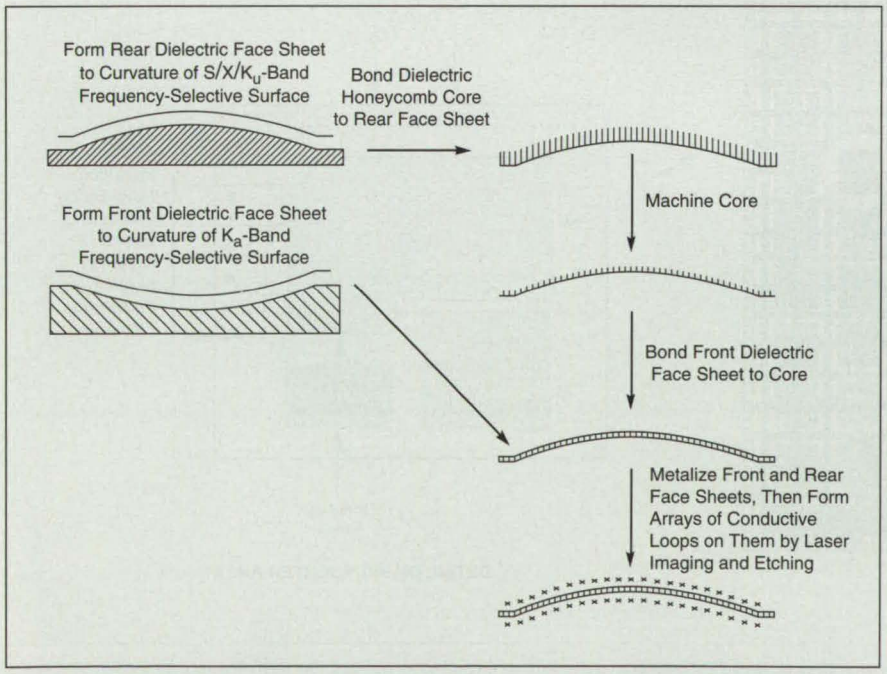

Figure 2. A **Curved Dichroic Microwave Reflector** is formed by photolithographically defining patterns of conductive-loop antenna elements on curved face sheets.

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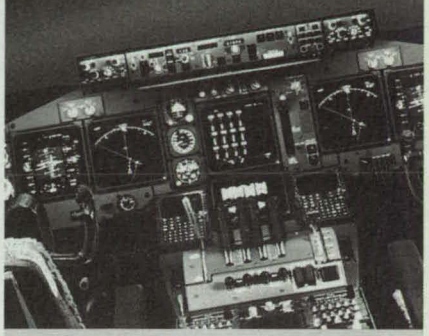

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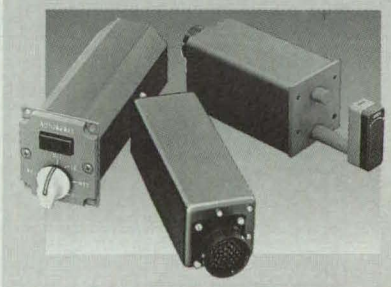

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Prototype Focal-Plane-Array Optoelectronic Image Processor

Advantages of optical and electronic processing are combined.

NASA's Jet Propulsion Laboratory, Pasadena, California

A prototype very-large-scale integrated (VLSI) planar array of optoelectronic processing elements combines the speed of optical input and output with the flexibility of reconfiguration (programmability) of an electronic processing medium. The basic concept of this processor was described in "Optical-Input, Optical-Output Morphological Processor" (NPO-18174), *NASA Tech Briefs*, Vol. 16, No. 11 (November 1992), page 52.

This processor performs binary operations on binary (black and white) images. Each processing element corresponds to one picture element of an image and is located at that picture element. Each processing element includes an input-plane photodetector in the form of a parasitic phototransistor that is part of a processing circuit (see figure). The output of each processing circuit would be used to modulate one picture element in an output-plane liquid-crystal display device, which had not yet been built when the information for this article was reported.

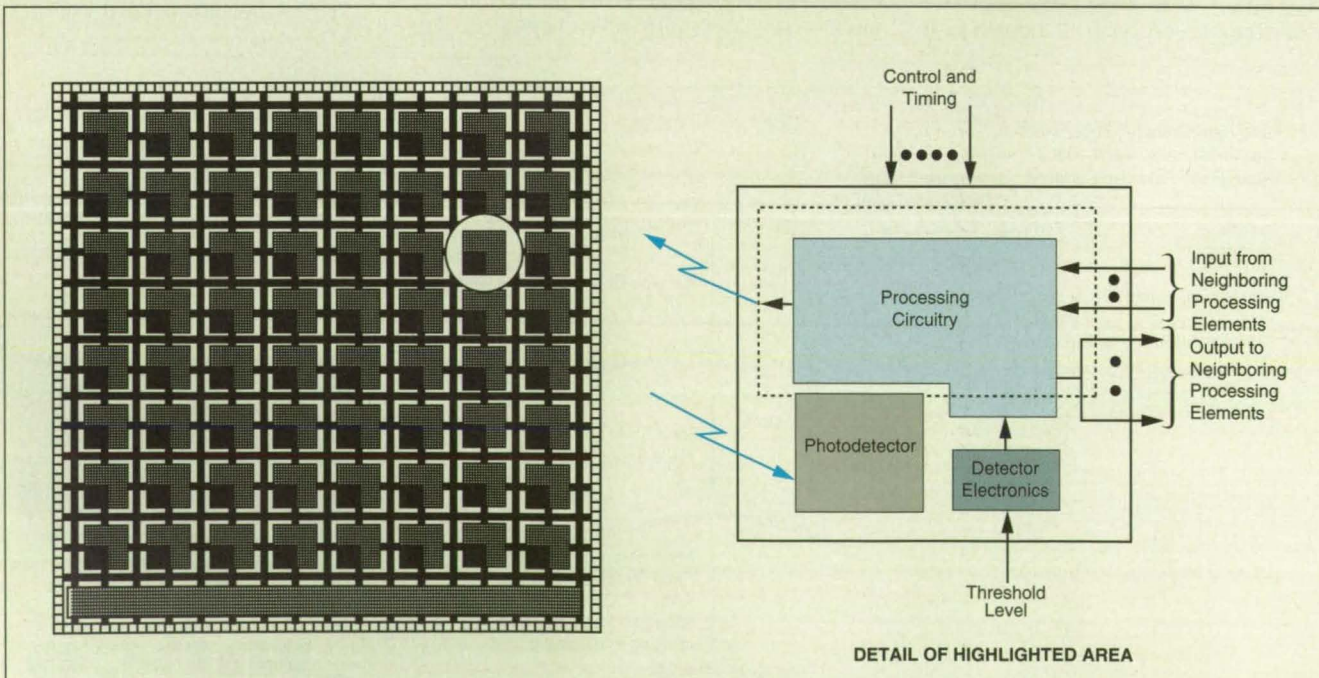
This processor is intended to implement morphological processing algorithms that transform an image into a set of features suitable for high-level processing; e.g., recognition. Morphological processing has been shown to be capable of removing noise and clutter and of editing an image on the basis of the sizes and shapes of objects of interest.

Morphological operations do not involve global communication of image data among all picture elements; only local data connections between adjacent picture elements are needed. Consequently, rapid morphological processing is readily implementable in a parallel optoelectronic architecture like that of this processor. In contrast, morphological image-processing algorithms, when executed on general-purpose computers, are extremely computationally intensive, and it is, therefore, difficult to execute them at video frame rates.

The processor includes a control circuit that generates clock and control strobe signals for the processing elements in the array on the basis of the high-level morphological instructions to be executed. A 4-bit control word is fed into the control circuit to specify the operations to be performed. This control word is decoded to provide the control signals needed for each operation. Each time a command strobe signal is activated, the control word selects one of the morphological operations, which is executed by all of the morphological processors in parallel.

The prototype morphological processor was fabricated in complementary metal oxide/semiconductor (CMOS) VLSI circuitry, using 2-μm design rules. The prototype circuit chip measures 1.2 by 1.2 mm and contains an 8 by 8 array of processing elements. Its digital circuitry operates at a rate of 40 MHz, which is sufficient for real-time processing of images at a video frame rate of 1 kHz.

This work was done by Wai-Chi Fang, Timothy Shaw, and Jeffrey Yu of Caltech for **NASA's Jet Propulsion**



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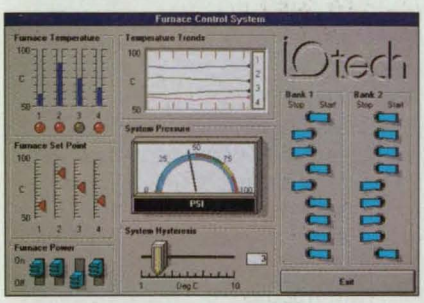

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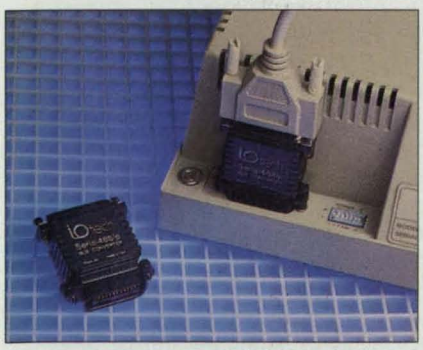

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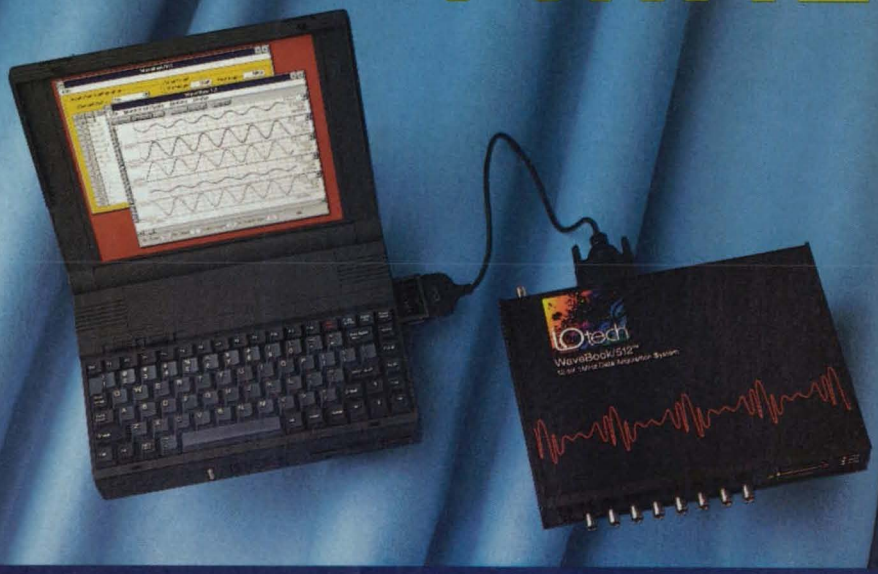

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Refer to NPO-18941, volume and number of this NASA Tech Briefs *issue, and the page number.*

Satellites Would Transmit Power by Laser Beams

Arrays of diode lasers would concentrate power into narrow beams.

Langley Research Center, Hampton, Virginia

The concept of transmitting power by laser beams in outer space has received a major stimulus from the recent emergence and rapid advance of the technology of laser-diode arrays. The basic idea is to use a nuclear, solar, or other source of power to generate a powerful laser beam and transmit the beam, collimated and focused, to locations where its power can be used as is or converted to such other forms as electrical or thermal. Conceivably, one such power system could serve the needs of many consumers, as do central electric power stations on Earth. Further, such systems may provide the best means of accomplishing a scientific mission or offer capabilities not otherwise available.

Such a laser-beam power system (see figure) would likely include a solar collector/concentrator, a solar photovoltaic array, a laser, beam-transmission optics, heat radiators, and a receiver/converter. The baseline design of the system was formulated with regard to two particular missions that differ greatly in power requirements, thus showing the scalability and attributes of the basic system. The two missions are the provision of 1 MW of power to a lunar habitat and the provision of 75 kW to a large lunar rover.

The satellites for both missions would circularly orbit the Moon 2,000 km above its surface, a distance compatible with current aiming technology and with the capability to transmit power continuously by use of three identical satellites to any point in view on the lunar surface. Inclinations of the orbits to the lunar pole would be chosen to ensure almost continuous solar illumination of the satellites and produce an orbital precession that would make every point on the lunar surface accessible to transmission of power at some time.

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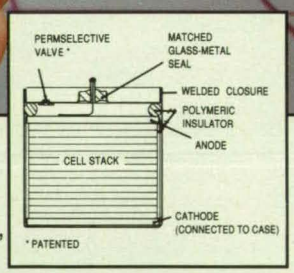

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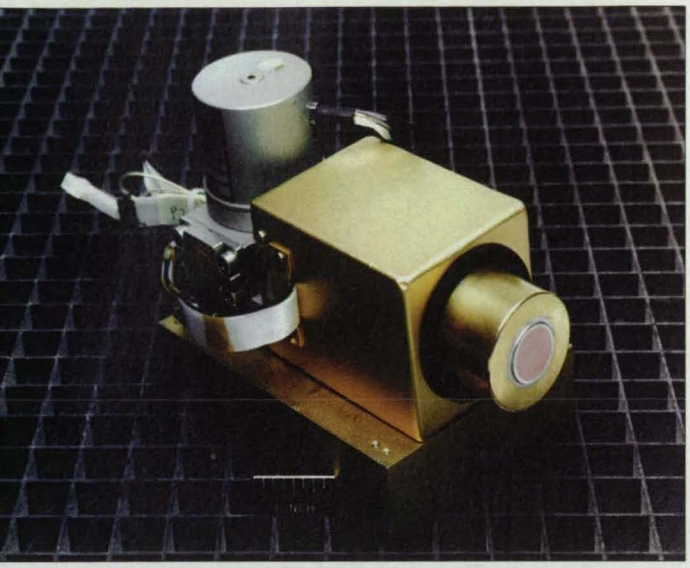
Infrared Engine



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features realizable within a decade.

Though this baseline design concept applies to lunar missions, such satellites could be used at other locations in the solar system for other missions. For example, they could provide power at the asteroid belt, which is expected to be a source of raw materials for future development in outer space. For Earth itself, they offer pollution-free power for the projected demands of emerging nations in the next several decades.

This work was done by M. D. Williams, Gilbert H. Walker, and D. H. Humes of **Langley Research Center** *and J. H. Kwon of Miami University. Further information may be found in NASA TP-2992 [N90-24585/TB], "Diode Laser Satellite Systems for Beamed Power Transmission."*

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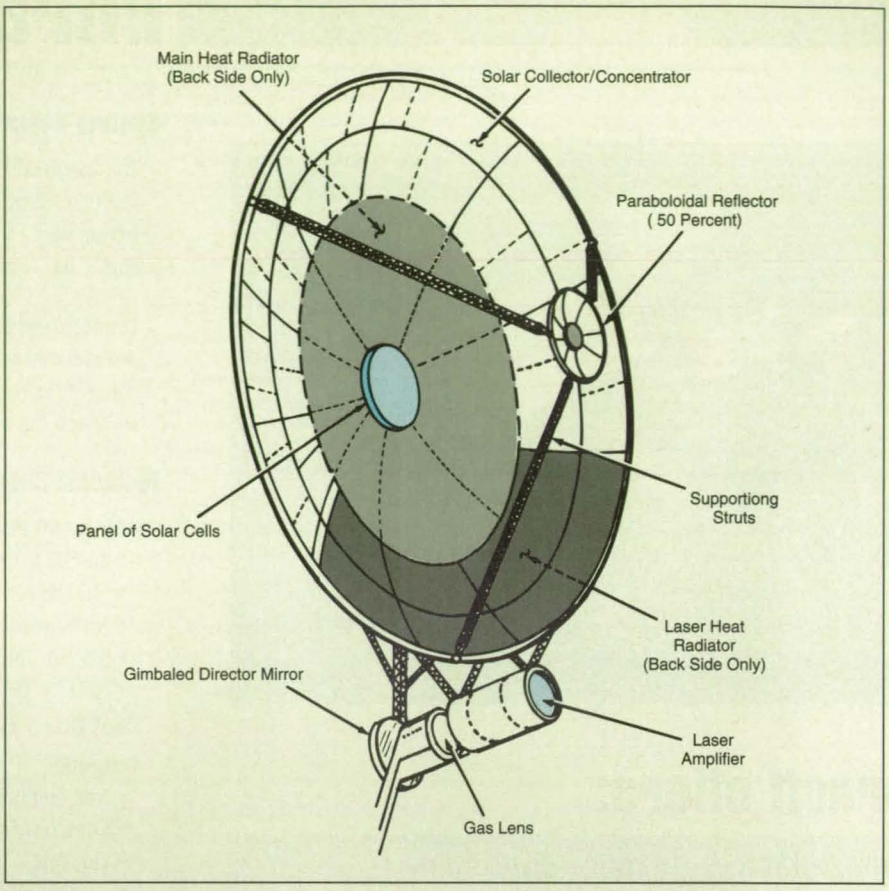

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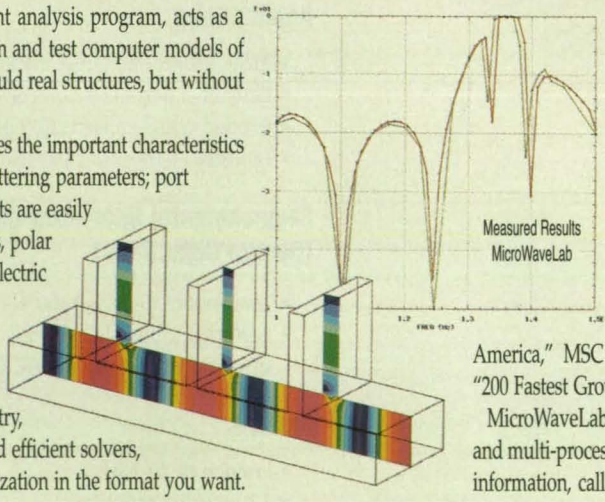

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Hardware and Software for Development of Robot Arms

Simulated results of commands can be viewed in three dimensions.

Marshall Space Flight Center, Alabama

A system of modular, reusable hardware and software has been assembled for use in developing remotely controlled robotic arms. The system includes (1) a central computer and its peripheral equipment at a control and monitoring station and (2) a remote mechanical platform that supports a robotic arm. The central computer controls the motor drives of the robotic arm, but optionally, the platform can hold an on-board computer for autonomous operation. The system consists mostly of commercial hardware and software.

The remote mechanical platform is 25 in. (63.5 cm) long, 18 in. (45.7 cm) wide, and 9 in. (22.9 cm) high. It can support equipment weighing a total of 100 lb (45.4 kg). In addition to the robotic arm, the platform holds a stereoscopic pair of color television cameras, equipped with stereoscopic microphones, that are controlled by, and send images to, the central computer. A wireless audio/video-distribution subsystem sends the audio and video signals to the central computer. Another wireless communication subsystem carries command signals from the central computer to the platform over two channels. The commands for each channel are generated by use of a joystick controller. On the platform, proportional motors operate the switches of power motors for steering and propulsion.

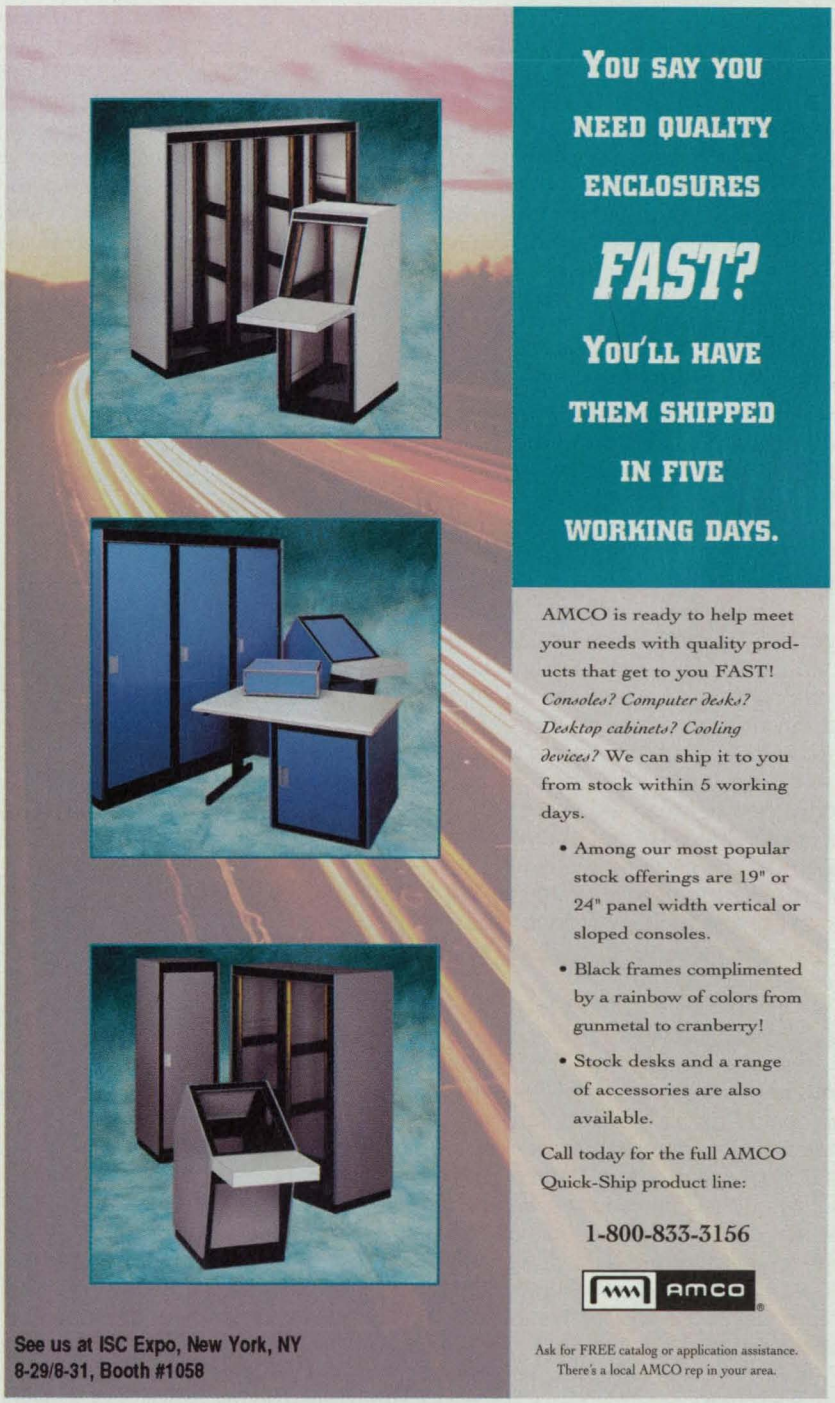
The central computer is an IBM-compatible unit with a 486DX2 66-MHz central processing unit, a local bus, a 340MB hard drive, a color monitor, 8MB of random-access memory (RAM), a double-speed compact-disc read-only memory, and two frame grabbers. Each frame grabber accepts signals from one of the television cameras, digitizes them, and stores them in an internal RAM in 1/30 s. Together the two frame grabbers provide live stereoscopic vision with 640-by-480-pixel resolution. Viewing the monitor through a three-dimensional visor, the operator has a sense of full-scale, real-time operation of the remote robot on the platform.

The display is presented in a window by Microsoft Windows software. The multitasking software concurrently provides supporting scene models, driving guidance, graphics, and auxiliary data. The computer also uses specially developed programs to generate depth maps of scenes and to create simulated three-dimensional scenes in motion.

This work was done by Daniel Usikov of the International Science Exchange Agency for **Marshall Space Flight Center**.

For further information, ***write in 79*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26337.



Thermoelectric Control of Temperatures of Pressure Sensors

Sensors are heated or cooled, depending on ambient and set-point temperatures.

Langley Research Center, Hampton, Virginia

A prototype controlled-temperature enclosure containing thermoelectric devices has been developed to house an electronically scanned array of pressure sensors. Such an enclosure is needed because (1) the temperatures of the transducers in the sensors must be maintained at a specified set point to ensure proper operation and calibration and (2) the sensors are sometimes used to measure pressure in hostile environments (wind tunnels in the original application) that are hotter or colder than the set point. Thus, depending on the temperature of the pressure-measurement environment, the thermoelectric devices in the enclosure are used to heat or cool the transducers to keep them at the set point.

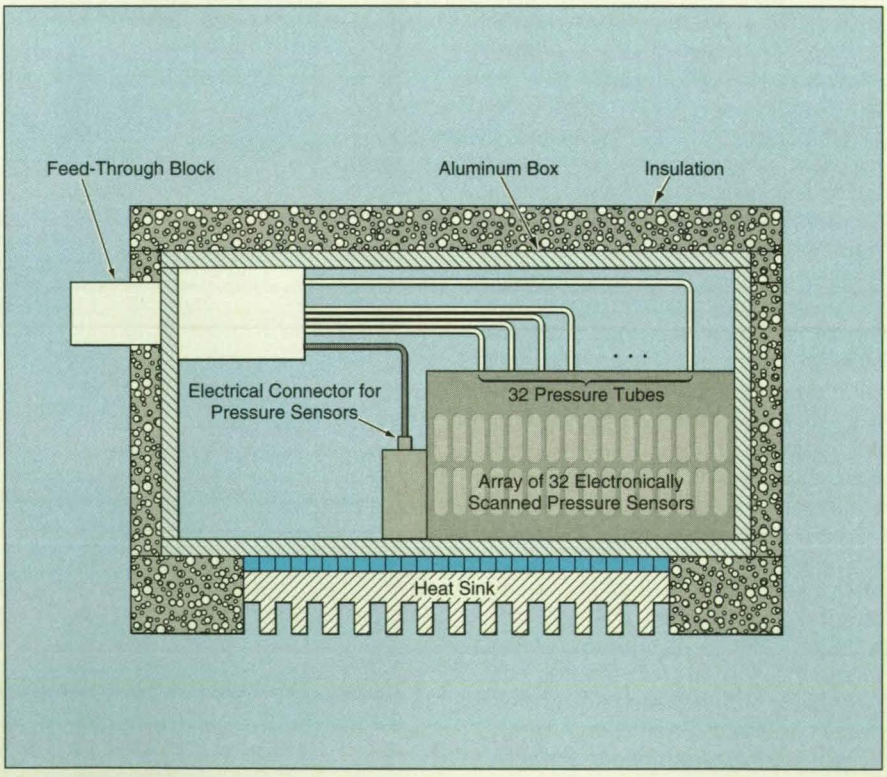
The enclosure (see figure) includes an aluminum box with walls 0.125 in. (3.2 mm) thick, encased in insulating foam 1 in. (25 mm) thick. The top of the enclosure is removable to provide access to the inside. The temperature in the sensor assembly is monitored, for the purpose of control, by use of a resistance temperature device (RTD). Single-stage thermoelectric heat pumps are thermally bonded and sandwiched between the underside of the aluminum box and a heat-sink plate. The number of thermoelectric devices used is directly related to the number of electronically scanned pressure-sensor modules to be kept at a controlled temperature.

The temperature in the box is controlled by varying the currents supplied to the thermoelectric devices in response to the reading of the RTD: The control circuit is an autotune proportional-plus-integral-plus-derivative (PID) dual-linear-output temperature controller (one output for heating and one for cooling); the outputs of the control circuit are fed to a variable 400-W bipolar dc power supply that, in turn, feeds power to the thermoelectric devices.

The prototype enclosure was tested in a laboratory in two phases. In the first-phase tests, a dummy electrical heater was used as a thermal load, instead of an assembly of pressure sensors. The second-phase tests were performed with an operational pressure-sensor assembly installed. In these tests, the enclosure was tested in an environmental test chamber in which the temperature was varied from -185 to 60 °C (-301 to 140 °F), while the temperature of the pressure sensors was held at various set points between 10 and 30 °C (between 50 and 86 °F), and the pressure ranged up to 93 kPa (9 atm).

The prototype enclosure was also tested in the National Transonic Facility wind tunnel at the same temperatures and pressures. For these tests, the heat-sink plate was mounted directly on the tunnel wall. Pressure tubing and associated control wiring were bundled and passed through a slotted aluminum block to the exterior of the box.

Both the laboratory and tunnel tests showed that the temperature in the pressure sensors can be maintained within ±0.5 °C (±0.9 °F) of any set point in the set-point range mentioned above (this range of 10 to 30 °C was selected to optimize both the heating and cooling capabilities of the thermoelectric devices).



The **Thermoelectrically Cooled or Heated Enclosure** maintains the pressure sensors within ±0.5 °C of a preset temperature in the presence of wide variations in the ambient temperature.

This work was done by Cecil G. Burkett, Jr., James W. West, and Mark A. Hutchinson of **Langley Research Center**, *and Robert M. Lawrence and James R. Crum of Wyle Laboratories. For further information,* ***write in 54*** *on the TSP Request Card. LAR-15389*

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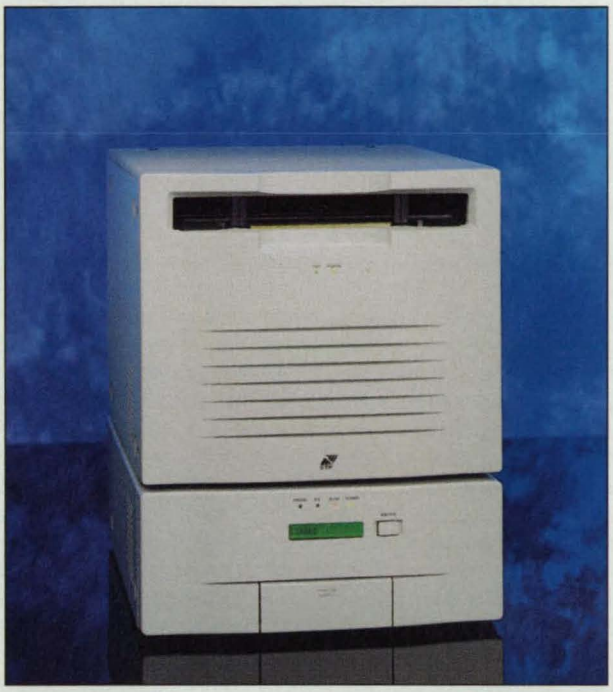

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Stabilizing Optical Path Length on a Vibrating Structure

Interferometry and feedback control reduce path-length disturbances.

NASA's Jet Propulsion Laboratory, Pasadena, California

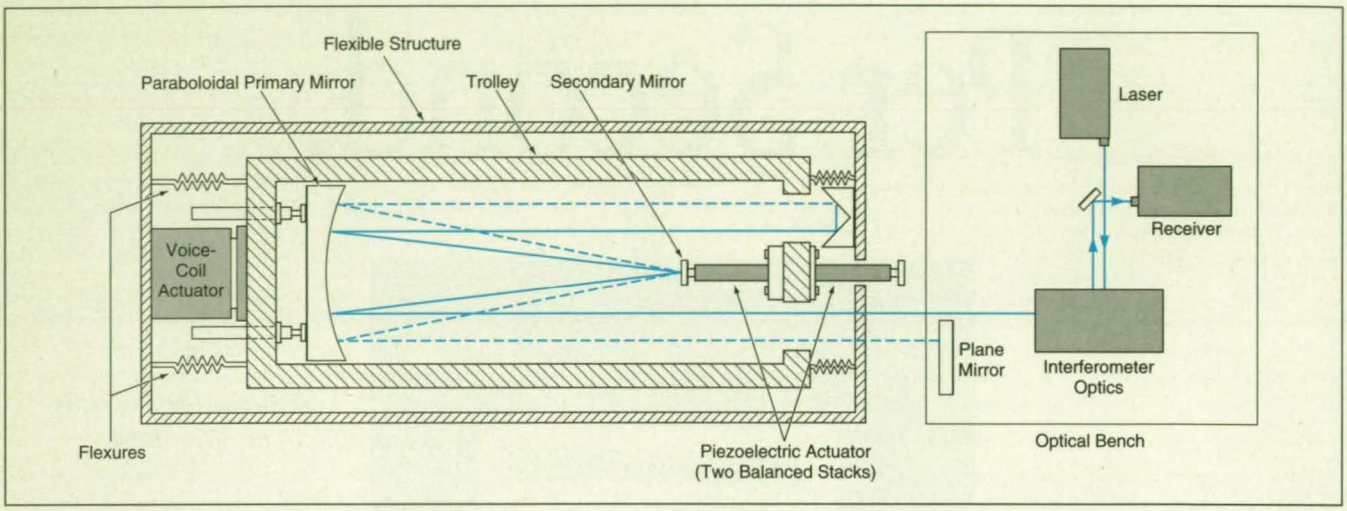

Figure 1. **Actuators Compensate for Variations** in the length of the interferometric optical path.

The prototype apparatus shown schematically in Figure 1 was constructed to test the feasibility of a feedback control concept for stabilization of the length of the optical path between two points on a vibrating flexible structure. In the original intended application, the structure would be a truss that has dimensions of the order of meters and that supports optical components of a stellar interferometer. The basic requirement upon the feedback control system is to reduce optical-path-length disturbances to the nanometer level to maintain the precision needed for stellar interferometry. This feedback control concept may also prove applicable to other large optical instruments in which it is required to maintain precise path lengths without having to use massive, expensive structures to obtain the rigidity necessary for precision.

Some aspects of the present feedback control concept and the prototype apparatus were described in "Controllable Optical Delay Line for Stellar Interferometry" (NPO-18686), *Laser Tech Briefs*, Vol. 1, No. 1 (September, 1993), page 44 and "Test Bed for Control of Optical-Path Lengths" (NPO-18487), *Laser Tech Briefs*, Vol. 2, No. 1 (Winter, 1994), page 61. In the prototype apparatus, the optical path lies within an interferometer that includes stationary interferometric optical components on an optical bench, plus a retroreflective assembly of optical components on a trolley attached to the free upper end of a tower-like cantilevered flexible structure. The interferometric components on the optical bench measure changes in the length of the optical path, thus providing a feedback signal.

The trolley contains two optical-path-length actuators; a voice-coil actuator connected between the trolley and the structure, and a piezoelectric actuator that moves a small, flat secondary mirror within the trolley. The piezoelectric actuator is used to compensate for small, high-frequency vibrations. The voice-coil actuator is used to compensate for low-frequency vibrations and keep the trolley positioned so that the desired constant optical-path length lies within the small dynamic range of the piezoelectric actuator. The dynamic response of the optical path length to the piezoelectric-actuator input is not affected significantly by the dynamics of the flexible structure because the mass of the secondary mirror is small and the piezoelectric-actuator stack is balanced for momentum compensation.

The input to the piezoelectric actuator is generated by processing the optical-path-length feedback signal through a digitally synthesized filter that implements a gain and frequency response represented by transfer function $K_1(s)$ (where s denotes the Laplace-transform complex frequency). The input to the voice-coil actuator is generated by processing the piezoelectric actuator input through a second filter of transfer function $K_2(s)$ (see Figure 2). Unlike in the design of many control systems, the transfer functions are not designed from a parametric model of the dynamics of the structure and actuators: instead, they are synthesized from measurements of the frequency responses of the optical path length to voice-coil-actuator and piezoelectric-actuator inputs. The objective in designing $K_1(s)$ and $K_2(s)$ is to make the closed-loop system stable and make the total loop gain as large as possible over the largest achievable frequency range.

Initial experiments on the prototype showed that the system can reduce, to the level of tens of nanometers, the path-length disturbances caused by forced vibrations at levels of tens to hundreds of microns.

This work was done by John T. Spanos and Zahidul H. Rahman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 153*** *on the TSP Request Card. NPO-19040*

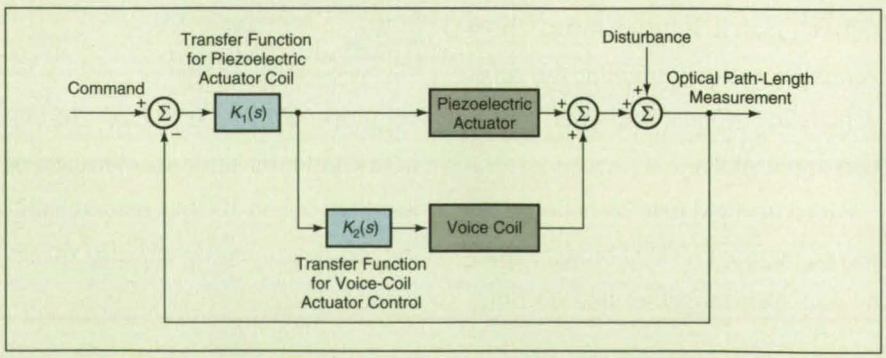

Figure 2. The **Feedback Control Loop** is implemented digitally to effect transfer functions with the desired gains and frequency responses based on the measured frequency responses of the system.

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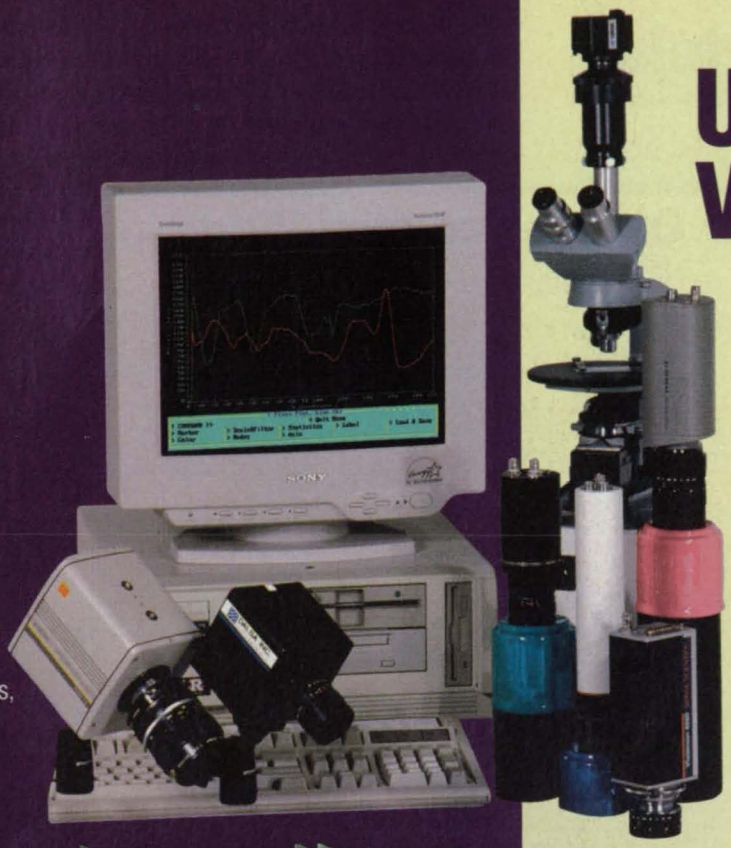

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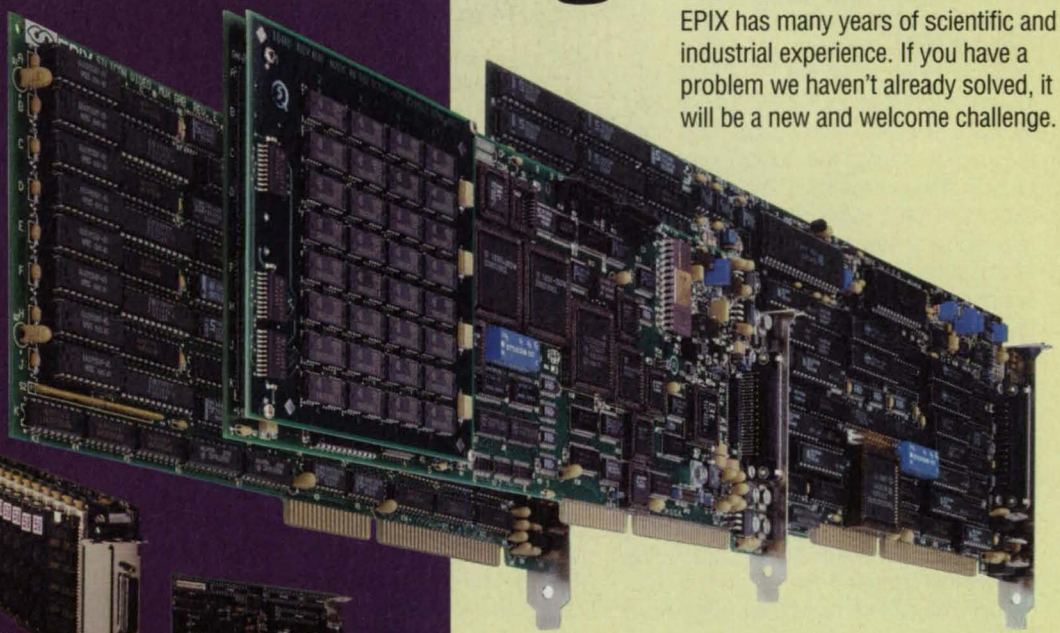

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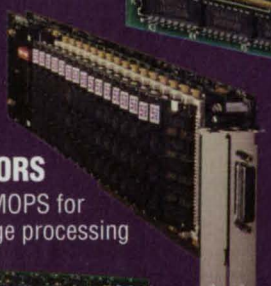

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Replacements for Ozone-Depleting Foaming Agents

Fluorinated ethers can be used in place of chlorofluorocarbons and hydrochlorofluorocarbons.

Marshall Space Flight Center, Alabama

Two fluorinated ethers are being investigated as potential replacements for the chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) blowing agents that are now used in the manufacture of polyurethane foam. Replacement is necessary because CFC's and HCFC's have been found to contribute to depletion of ozone from the upper atmosphere, and the manufacture and use of them are required by law to be phased out in the near future.

The two fluorinated ethers in question do not have ozone-depletion potential and can be used in existing foam-producing equipment, which is designed to handle liquid blowing agents that are soluble in the chemical ingredients that are mixed to make the foam. These fluorinated ethers (see table) are $CH_3CH_2OCHF_2$ (called "E245") and $CF_3CH_2OCH_3$ (called "E263"). They are compatible with both the isocyanate and the polyol ingredients of polyurethane foams. E245 is relatively expensive and, when released into the atmosphere, has a characteristic lifetime of about 6 years. E263 is relatively inexpensive and has an atmospheric lifetime of about 2 months. In other respects, their properties are similar.

The gelling times and densities of polyurethane foams made with these fluorinated ethers are similar to those made with CFC-11 and HCFC-141b. Furthermore, the foams made with the fluorinated ethers have superior cellular structures with finer cells. Any polyurethane-based foams and several cellular plastics can be blown with these fluorinated ethers which can be used in processes as diverse as small batch pours, large sprays, or double-band lamination to make insulation for private homes, commercial buildings, shipping containers, and storage tanks, for example. Fluorinated ethers may also prove useful as replacements for CFC refrigerants and solvents.

	$CH_3CH_2OCHF_2$ (E245)	$CF_3CH_2OCH_3$ (E263)
Molecular Weight, Daltons	150	114
Specific Gravity	1.146	1.160
Boiling Temperature, °C	29	30
Atmospheric Lifetime	6 Years	2 Months
Flash Point (Temperature in °C)	None	– 16 °C
Solubility in Isocyanate, Weight Percent	13	>20
Solubility in Polyol, Weight Percent	No Limit	Between 26 and 50
Relative Cost of Production	High	Low

Selected Properties of Two Fluorinated Ethers are listed to show their suitability as replacements for CFC-11 and HCFC-141b as blowing agents in polyurethane foams.

Initially, there was concern that the two fluorinated ethers would form peroxides upon aging and exposure to air, even though their long atmospheric lifetimes would seem to preclude this (the long-chain ethers that typically form peroxides have lifetimes measured in hours). Attempts to form peroxides by oxygenating the materials yielded negative results; that is, no peroxides were detected. Preliminary tests of toxicity showed that these fluorinated ethers should be handled similarly to other ethers—with adequate ventilation, taking account of their anesthetic effects. Other toxic effects, like carcinogenicity (if any), have not yet been investigated.

This work was done by Elana Blevins and Jon B. Sharpe of Martin Marietta Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 95*** *on the TSP Request Card.*

MFS-28805

N-Butane To Replace Trichlorotrifluoroethane

The only significant disadvantage is flammability.

Lyndon B. Johnson Space Center, Houston, Texas

According to a proposal, trichlorotrifluoroethane would be replaced by n-butane as a solvent for removal of oils, greases, hydraulic fluids, and other oily surface contaminants. Trichlorotrifluoroethane is also called "refrigerant 113," "CFC-113," and variants thereof. It is one of a number of chlorofluorocarbon fluids sold under the trade name "Freon." Trichlorotrifluoroethane must be replaced because, like other chlorofluorocarbons, it contributes to depletion of ozone from the upper atmosphere. Another factor that motivates replacement is cost: trichlorotrifluoroethane costs about $127 per gallon

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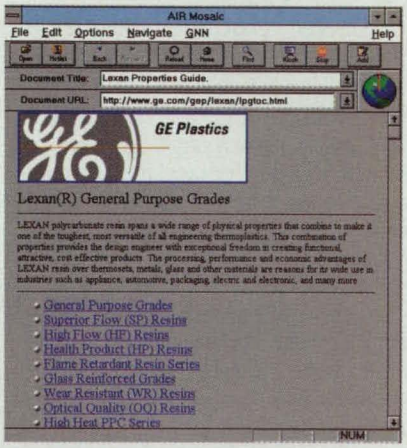

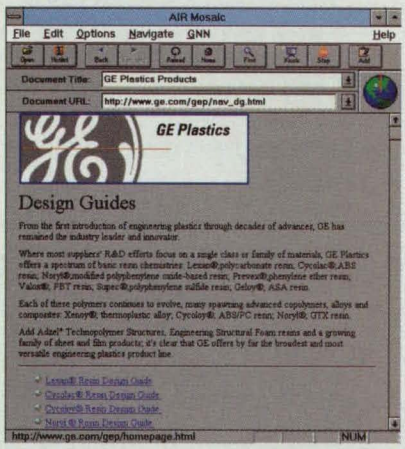

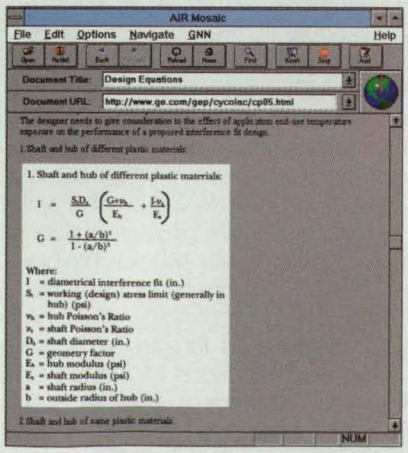

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($34 per liter, 1994 prices).

N-butane is a candidate replacement fluid because those of its physical and chemical properties that are relevant to use as a solvent are similar to the corresponding properties of trichlorotrifluoroethane. N-butane is also considerably less expensive; it costs about $5 per gallon ($1.30 per liter), the exact cost depending on the degree of purity. The only major disadvantage of n-butane is its flammability. As in the cases of other hydrocarbon fluids, the flammability hazard can be minimized by engineering controls.

In addition to having wetting ability, surface tension, heat of vaporization, and vapor pressure suitable for use as a good cleaner, degreaser and cleanliness-certification solvent, n-butane is noncorrosive and is compatible with metals and soft goods. It also leaves very little nonvolatile residue, exhibits low toxicity, and evaporates about as quickly as trichlorotrifluoroethane does.

Like trichlorotrifluoroethane, liquid n-butane can be handled easily while wearing normal laboratory attire. It is easily extractable in that it boils at a temperature of -0.5 °C. It also exhibits a high degree of filterability, so that it can easily be filtered to obtain a count of particles suspended in it.

This work was done by Paul H. Biesinger of Lockheed Engineering and Sciences Co. for **Johnson Space Center.** *For further information,* ***write in 30*** *on the TSP Request Card. MSC-22517*

Hydrophobic, Porous Battery Boxes

Corrosive, toxic electrolytes are contained safely, while gases are allowed to flow in and out.

Lyndon B. Johnson Space Center, Houston, Texas

Boxes made of porous, hydrophobic polymers have been developed to contain the aqueous potassium hydroxide electrolyte solutions of zinc/air batteries while allowing air to diffuse in as needed for operation. Boxes like these could also be used on other types of batteries for in-cabin use in which the electrolytes are aqueous and from which gases generated during operation must be vented without allowing the electrolytes to leak out. Examples include silver/zinc, alkaline/manganese, nickel/cadmium, nickel/metal hydride, and lead/acid batteries, all of which emit hydrogen.

The predecessors to the present polytetrafluoroethylene boxes were made of nonporous polycarbonate and featured vent holes covered with gas-permeable, liquid-impermeable caps. These caps were made of polymeric laminates that included porous polytetrafluoroethylene films, and they were bonded adhesively to the boxes. Because of the nature of the materials used, it was difficult and often impossible to make leak-tight adhesive bonds. As a result, the boxes were susceptible to leakage of electrolyte at the vent holes.

A box of the present type is molded in two pieces: one piece comprises the bottom and sides; the other piece is the top. Both pieces are made from a hydrophobic fluorinated polymeric powder, e.g., poly(tetrafluoroethylene) or poly(vinylidene fluoride) powder. The powder is sintered, rather than melted as in injection molding, to give the molded pieces a porous microstructure similar to that of the polystyrene foam used in some coffee cups. The pores allow gases to pass through, while the hydrophobicity prevents the aqueous electrolyte from passing through.

The two pieces of the box are bonded adhesively by use of an epoxy cement. Epoxies do not ordinarily adhere to smooth poly(tetrafluoroethylene) surfaces, but in this case, the surface is not smooth: The epoxy readily forms a bond to the microscopically rough surface of the porous box material.

This work was done by Bobby J. Bragg of **Johnson Space Center** *and John E. Casey, Jr., of Lockheed Engineering and Sciences Co. For further information,* ***write in 83*** *on the TSP Request Card. MSC-22389*

Temporally and Thermally Stable Iron/Nickel Alloy

High-purity processing imparts an unusual combination of properties.

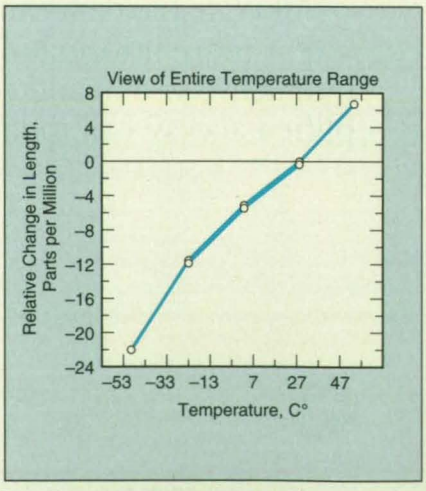
NASA's Jet Propulsion Laboratory, Pasadena, California

A specially prepared version of a commercial low-thermal-expansion iron/nickel alloy exhibits unprecedented thermal and temporal dimensional stability. Commonly designated by its trade name, Invar 36, this alloy has a nominal composition of 64 percent iron and 36 percent nickel. The special preparation consists of a high-purity powder-metallurgy process followed by a heat treatment. The carbon content of the specially prepared alloy is < 0.01 percent; the content of other impurities is also < 0.01 percent. The high purity of the alloy is essential for its unusual combination of properties.

The coefficient of thermal expansion (CTE) of a typical batch of this alloy is considerably less than 1×10^{-6}/°C (see figure), and the rate of relative temporal change in any of its linear dimensions (essentially, a slow shrinkage) is less than 10^{-6}/year. Previously, low CTEs were achieved by thermomechanical treatments that introduced temporal instabilities, so that low CTE and long-term stability have been mutually exclusive.

This work was done by Witold M. Sokolowski, Timothy P. O'Donnell, Marc S. Lane, and Cheng H. Hsieh of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 13*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL; (818) 354-5179. Refer to NPO-19358.



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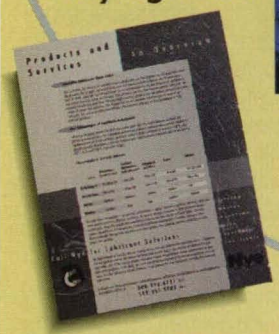

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Mathematics and Information Sciences

Genetic-Algorithm Tool for Search and Optimization

SPLICER facilitates the creation of genetic-algorithm application programs.

The SPLICER computer program is a genetic-algorithm tool that can be used to solve search and optimization problems. Genetic algorithms are adaptive search procedures (i.e., problem-solving methods) based loosely on the processes of natural selection and Darwinian "survival of the fittest." The algorithms apply genetically inspired operators to populations of potential solutions in an iterative fashion, creating new populations while searching for an optimal or nearly optimal solution to the problem at hand.

SPLICER provides the underlying software framework and structure for building a genetic-algorithm application program. SPLICER has a modular architecture that includes a genetic-algorithm kernel, interchangeable representation libraries, fitness modules and user-interface libraries, and well-defined interfaces among these components. The architecture supports portability, flexibility, and extensibility. SPLICER comes with all source code and several examples. For instance, a "traveling salesperson" example searches for the minimum distance through a number of cities, visiting each city only once. Stand-alone SPLICER application programs can be used without any programming knowledge. However, to utilize SPLICER fully within new problem domains, familiarity with C-language programming is essential.

The genetic-algorithm (GA) kernel in SPLICER was developed independent of representation (i.e., problem-encoding), fitness-function, or user-interface type. The GA kernel comprises all functions necessary for the manipulation of populations. These functions include the creation of populations and members thereof, the iterative population model, fitness scaling, parent selection and sampling, and the generation of population statistics. In addition, miscellaneous functions are included in the kernel (e.g., random-number generators). Different problem-encoding schemes and functions are defined and stored in interchangeable representation libraries. This enables the use of the GA kernel with any representation scheme. SPLICER provides representation libraries for binary strings and for permutations. These libraries contain functions for the definition, creation, and decoding of genetic strings, as well as multiple crossover and mutation operators. Furthermore, SPLICER defines the appropriate interfaces to enable users to create new representation libraries.

Fitness modules are the only components of the SPLICER system that a user needs to create or alter to solve a particular problem. Fitness functions are defined and stored in interchangeable fitness modules, which must be created by use of C language. Within a fitness module, a user can create a fitness (or scoring) function, set the initial values for various SPLICER control parameters (e.g., size of a population), create a function that graphically displays the best solutions as they are found, and provide descriptive information about the problem. SPLICER comes with several example fitness modules, while the process of developing a fitness module is fully discussed in the accompanying documentation. The user interface is event-driven and provides graphic output in windows.

SPLICER is written in Think C for Apple Macintosh computers running System 6.0.3 or later and Sun-series workstations running SunOS. The UNIX version is easily ported to other UNIX computers and requires MIT's X Window System, Version 11 Revision 4 or 5, MIT's Athena Widget Set, and the Xw Widget Set. Example executable codes and source code are included for each machine version. The standard distribution medium for the Macintosh version is a set of three 3.5-in. (8.89-cm) Macintosh-format diskettes. The standard distribution medium for the UNIX version is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in UNIX tar format. For the UNIX version, alternate distribution media and formats are available upon request. SPLICER was developed in 1991.

This program was written by Lui Wang of **Johnson Space Center** *and Steven Bayer of Mitre Corp. For further information,* ***write in 50*** *on the TSP Request Card. MSC-22009*

Mathematics and Information Sciences

System-Availability and Resource-Allocation Program

ACARA can be used to perform many types of analyses and trade studies.

ACARA is a computer program for analyzing availability, life-cycle cost, and scheduling of resources. It uses a statistical Monte Carlo method to simulate the capacity states of a system as well as the failure and repair of components. Failures of components are modeled mathematically by use of a combination of

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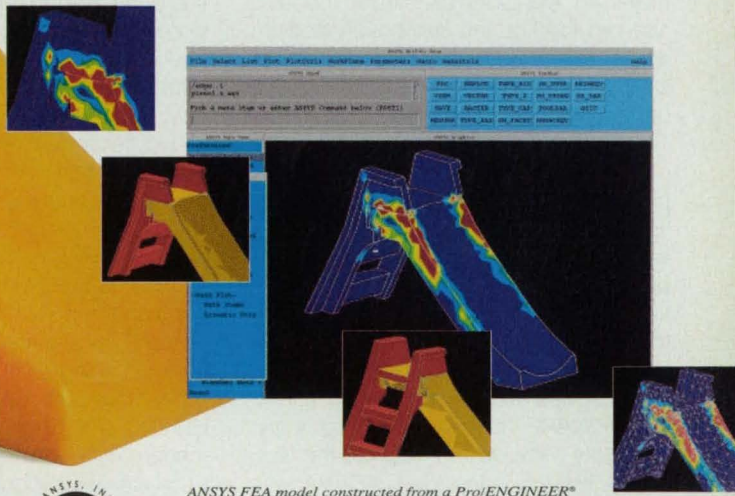

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exponential and Weibull probability distributions. ACARA schedules replacement of components to optimize the performance of the system. The scheduling can be made to comply with any constraints on the production of components, capacities of resupply vehicles, spares kept on site, crews, and/or equipment.

ACARA is capable of many types of analyses and trade studies because of its integrated approach. It characterizes the performance of a system in terms of both state availability and equivalent availability (a weighted average of state availability). It can determine the probability of exceeding a capacity state to assess reliability and probability of loss of load. It can also evaluate the effect of the constraints upon resources on the availability of the system and its life-cycle cost.

ACARA interprets the results of a simulation and displays tables and charts for (1) performance; i.e., availability and reliability of capacity states, (2) frequency of failure and repair, (3) life-cycle cost, including hardware, transportation, and maintenance, and (4) usage of available resources, including mass, volume, and person-hours spent on maintenance. ACARA incorporates an easy-to-use, menu-driven interface with full screen data entry. It provides a file-management system to store and retrieve sets of input and output data for system-simulation scenarios.

ACARA is written in APL2, using the APL2 interpreter, for IBM PC-compatible computers running MS-DOS. Hardware requirements for the APL2 system include 640K of random-access memory, 2 Mb of extended memory, and an 80386 or 80486 processor with an 80 × 87 math coprocessor. A dot-matrix printer is necessary for printing a graph from a results table. An MS-DOS executable code is also provided on the distribution medium and does not require extended memory, an 80386, or a math coprocessor. It can be used to model systems of limited size. The executable code contains licensed material from the APL2 for the IBM PC product, which is program property of IBM: Copyright IBM Corporation 1988 — all rights reserved. It is distributed with permission of IBM. The standard distribution medium for this program is a set of three 5.25-in. (13.34-cm), 360K MS-DOS-format diskettes. The contents of the diskettes are compressed by use of the PKWARE archiving software tools. The utility software to unarchive the files, PKUNZIP.EXE, is included. ACARA was developed in 1992.

This program was written by L. A. Viterna and D. K. Stalnaker of **Lewis Research Center.** *For further information,* ***write in 39*** *on the TSP Request Card. LEW-15713*

Mechanics

Estimating Noise Levels in an Enclosed Space

Contributions of multiple pieces of equipment at various locations and times are taken into account.

The GEGS Acoustic Analysis Program (GAAP) was developed to compute the composite profile of noise in the Spacelab module on the basis of data on noise produced by equipment, data on locations of equipment, and equipment-operating schedules. The impetus for the development of GAAP was provided by the noise that was generated in the Spacelab Module during the SLS-1 mission because of the concurrent operation of many pieces of experimental and subsystem equipment. The noise produced stress in the crew members. Although GAAP was originally intended specifically to help compute the noise in Spacelab, it is also applicable to any region in which there are multiple sources of noise.

Inasmuch as the composite profile of noise in the Spacelab module is a function of locations of equipment, times of turning equipment on and off, and reverberation characteristics of the enclosure that contains the equipment, a large number of data are generated in an analysis directed toward the generation of such a profile. Therefore, a graphical-interface subprogram was incorporated into GAAP to display the spatial distribution of the noise profile in a three-dimensional plot. The user can specify whether GAAP is to consider the direct sound field only, the reverberant sound field only, or both the direct and reverberant sound fields. GAAP is capable of using either the metric or the English system of measurement units.

GAAP is written in FORTRAN 77. It was originally developed for use on DEC VAX-series computers running VMS, but has also been successfully implemented on UNIX computers, including Sun computers running SunOS and DECstation-series computers running DEC RISC ULTRIX. The program requires 5MB of random-access memory for execution. Because this program puts out files in PostScript format, a means of viewing or printing PostScript files is necessary. The standard medium for distribution of GAAP is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. Alternate distribution media and formats are available upon request. GAAP was developed in 1992.

This program was written by Elias Azzi of General Electric Government Services for **Johnson Space Center.** *For further information,* ***write in 43*** *on the TSP Request Card. MSC-22306*

Mathematics and Information Sciences

Computing Tolerance Factors and Noncentral *t* Distribution

This program can be used in place of reference tables.

TF, the Tolerance Factors and Noncentral *t* Distribution computer program, computes the tolerance factor from a normal-distribution sample for an arbitrarily specified coverage probability, confidence level, and any positive (integer or noninteger) number of degrees of freedom. The program has been used extensively in engineering and quality analyses.

TF is menu-driven and implements four calculation routines: (1) one-sided tolerance-factor calculation; (2) two-sided tolerance-factor calculation; (3) noncentral *t* probability calculation; and (4) noncentral *t* percentage point calculation. The unique approach to the noncentral *t* routines is very computationally efficient. The use of the program compares favorably with the use of standard reference tables in terms of convenience, flexibility, and accuracy of results.

TF is written in Microsoft QuickBasic v2.0, and both an executable and a source code are included in the package. The only requirement for running the included executable code is an IBM PC*-compatible computer with an 80 × 87 math coprocessor. Compilation of the source code depends on the prior installation of the Microway 87SFL Math Function Software Library and MicroSoft QuickBasic V2.0 on the system. The standard distribution medium for this package is a 5.25-in. (13.335-cm), 360K MS-DOS**-format diskette. This program was developed in 1991.

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**MS-DOS is a trademark of Microsoft Corporation.

This program was written by Zhaofeng Huang of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 85*** *on the TSP Request Card. MFS-29839*

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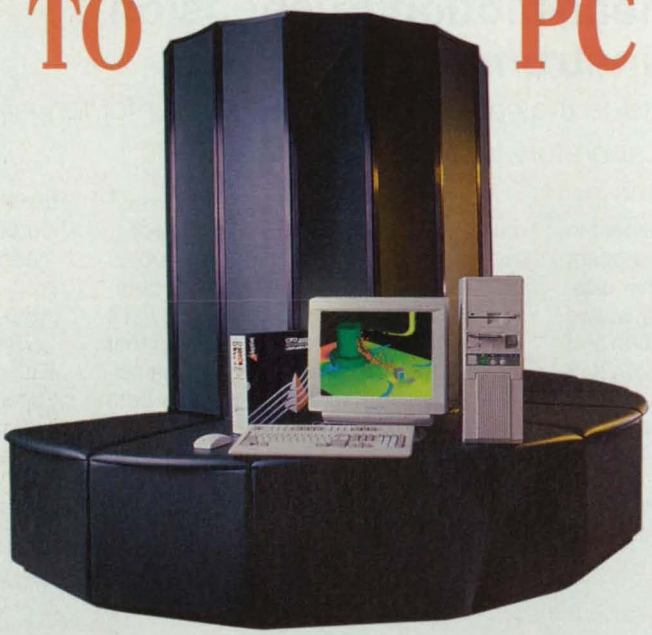

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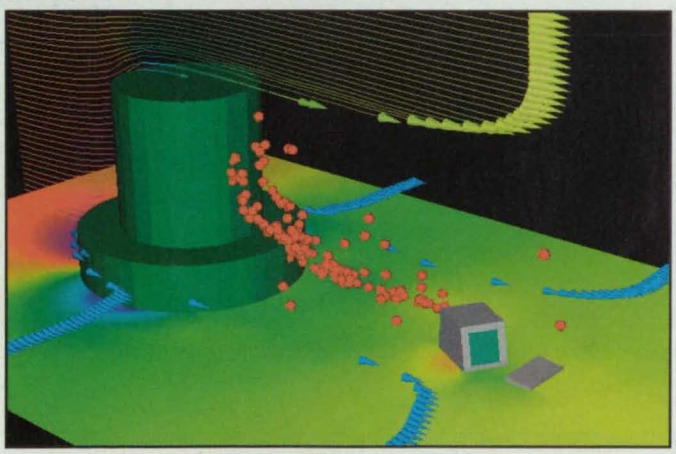

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Long-Lived Linear-Motion Suspension for Cryogenic Instrument

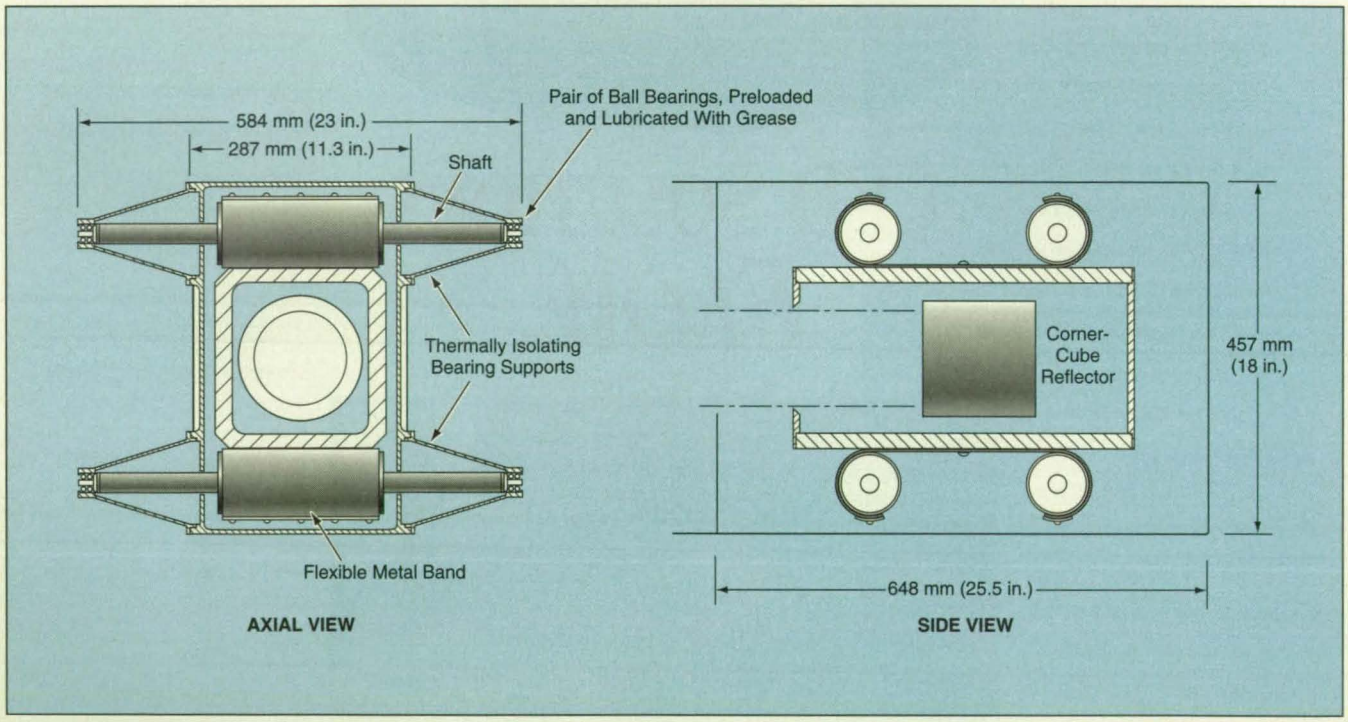
Bearings are located outside the cooled instrument chamber for longer life.

NASA's Jet Propulsion Laboratory, Pasadena, California

A mechanism suspends an optical component in a cryogenic instrument in such a way as to allow the component to translate smoothly along one axis, without vibration. The mechanism allows a maximum stroke of 7 in. (17.8 cm) and has a life expectancy of 10^7 in. (254 km) of travel, which should enable approximately 1.4 million strokes at the full 7-in. amplitude.

The optical component (a corner-cube reflector) and most of the mechanism are located within the cooled instrument chamber. The optical component moves on four rollers, to which it is attached via flexible metal bands that are wound onto the rollers (see figure). Each roller is mounted on a shaft, both ends of which extend to outside the cooled instrument chamber, so that bearings that support the shafts can be located outside the cryogenic environment for longer life. The shafts also act, in conjunction with the bearing supports, to provide thermal isolation.

This work was done by Douglas T. Packard and Michael L. Agronin of Caltech for **NASA's Jet Propulsion Laboratory.** *No further documentation is available. NPO-19284*



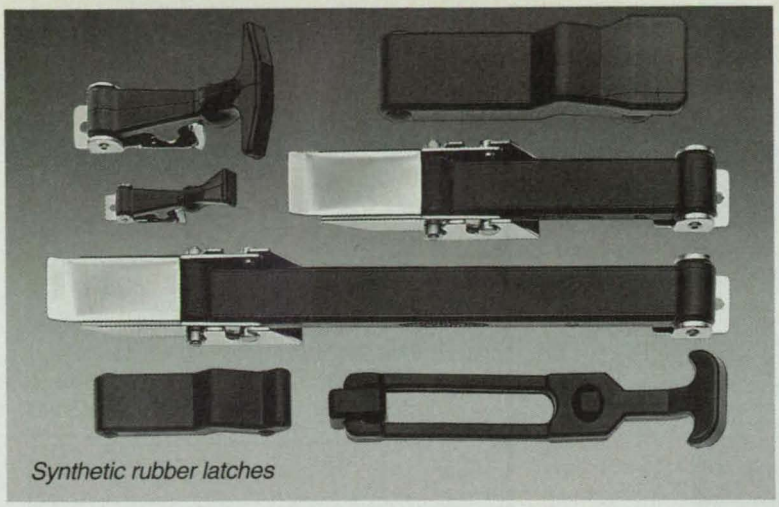
Thermal Isolators separate the bearings from the cryogenic environment inside the instrument chamber.

Fatigue-Arrestor Bolts

Interference fits introduce compressive preloads that retard fatigue by reducing the ranges of strains.

Marshall Space Flight Center, Alabama

Bolts that arrest (or, more precisely, retard) the onset of fatigue cracking caused by inelastic strains have been developed. The bolts were specifically developed to be installed in flange holes of an unrestrained rocket engine nozzle. The flanges in question are sometimes used to bolt the nozzle to the test stand; however, when the rocket engine is operated without this restraint, the region around the bolt holes experience severe inelastic strains causing fatigue cracking. The flange and bolts are made of an age-hardened nickel alloy, but the basic



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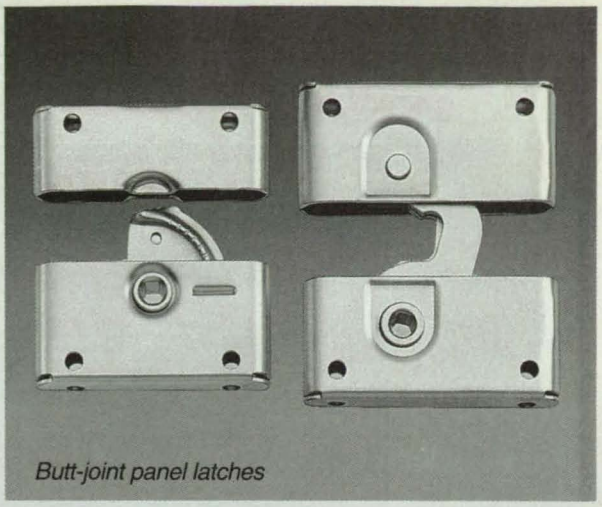

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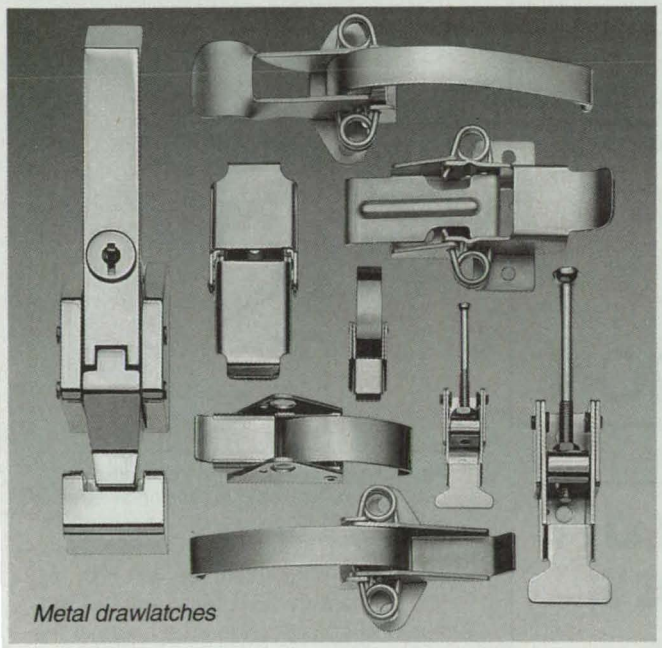

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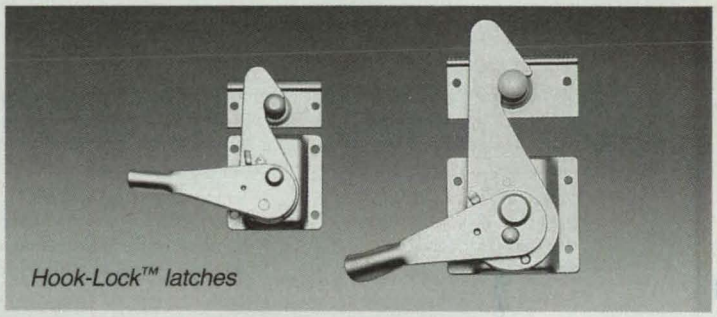

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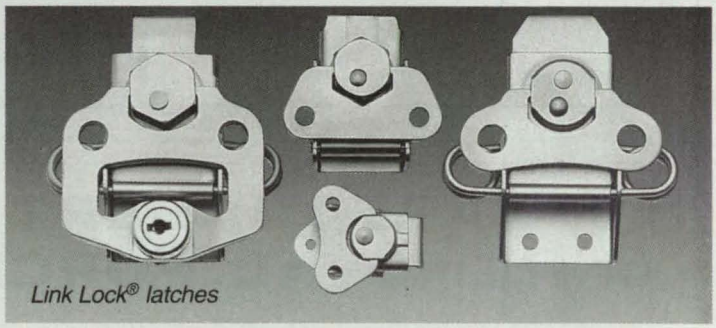

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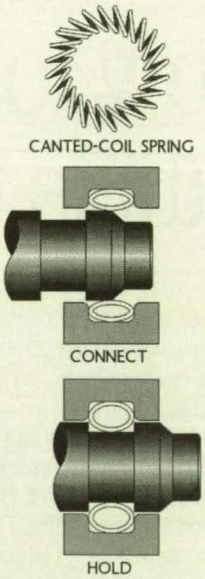

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principle of these fatigue-arrestor bolts should also be applicable to holes in plates made of other materials and/or used for different purposes.

The rocket engine is generally tested without bolting the aft end of the nozzle (flange location) to the test stand. During ignition, the leading edge of the combustion gas creates pressure differentials on the nozzle shell as it flows towards the exit plane of the nozzle. These pressure differentials cause the circular end of the nozzle to ovalize in a random manner. Any position around

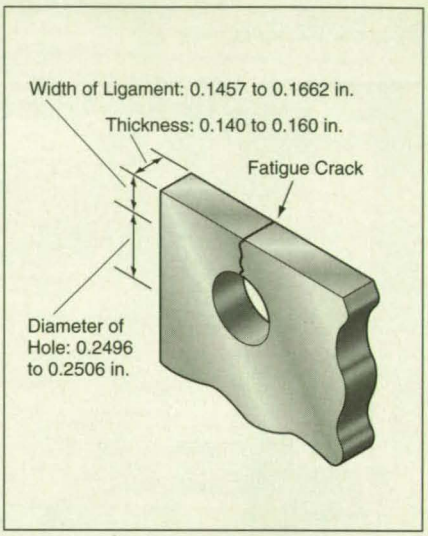

Figure 1. The **Crack in the Ligament** is typical of fatigue cracks that develop as a result of large cyclic loads applied to the bolthole.

the flange circumference experiences 100 or more stress strain cycles of tension and compression. The holes in the flange generate large stress concentrations (up to 3.6 times the nominal stress) which gives rise to fatigue cracks initiating in the ligament. The ligament is the narrow part of the flange above the bolt holes (see Figure 1). When installed, the fatigue-arrestor bolts retard the fatigue when the engine is operated in this unrestrained condition.

These fatigue-arrestor bolts use interference fit to retard fatigue accumulation. Similar interference fit assemblies have been used in industry to retard elastic fatigue in holes (where the alternating stresses are generally less than 50% the yield strength of the material). During an unrestrained engine start, the unrestrained hole experiences peak strains greater than three times the yield strength of the material. The bolt has a smooth shank made for an interference fit in the bolthole. The amount of the interference fit [the diameter of the bolt shank exceeds the 0.250-in. (6.35-mm) diameter of the bolthole by 0.0011 to 0.0020 in. (0.028 to 0.051 mm)] has been optimized by

For More Information Write In No. 419

experiments. The bolt is cooled in liquid nitrogen to shrink it, then quickly pressed into place in the bolthole before it warms up and expands to full size. The bolt is also held in the hole by a self-locking nut (see Figure 2).

The interference fit places the surrounding flange material under a compressive stress. This reduces the range of strains experienced by the ligament and thereby extends the low cycle fatigue life of the ligament. The concentrations of stress that would ordinarily occur around a hole in a plate are virtually eliminated for compressive loads, and are believed to be reduced for tensile loads as well. The interference fit causes the surrounding material to behave as though no hole exists until the tensile stress exceeds the compressive stress at the interface between the bolt and the hole.

The increase in fatigue life afforded by the fatigue-arrestor bolts was demonstrated by stress cycling of identical specimens with and without fatigue-arrestor bolts installed in the holes. Of twelve specimens tested with fatigue-arrestor bolts, the lives increased by factors ranging from 8.9 to more than 90. The wide variation in these observed values is attributed to the difficulty of reproducing identical interference fits and to the use of different strain ranges.

This work was done by Joseph W. Onstott, Mark Gilster, Sergio Rodriguez, John E. Larson, Mark D. Wickham, and Kevin E. Schoonover of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 74*** *on the TSP Request Card.*
MFS-30068

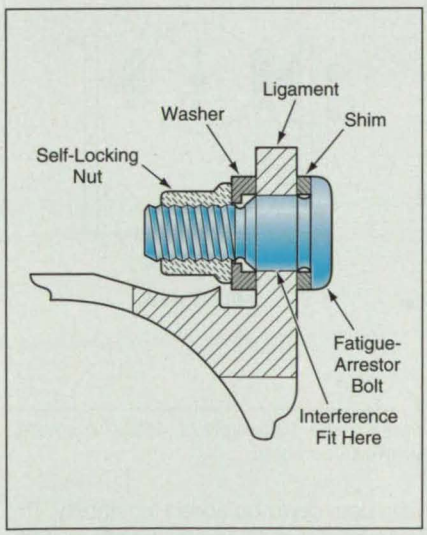

Figure 2. The **Interference Fit** of the bolt shank in the hole reduces fatigue by reducing the range of strains in the material surrounding the bolthole.

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Auxiliary Control Mechanisms for RUM Actuators

Weights, power demands, and costs would be reduced.

Marshall Space Flight Center, Alabama

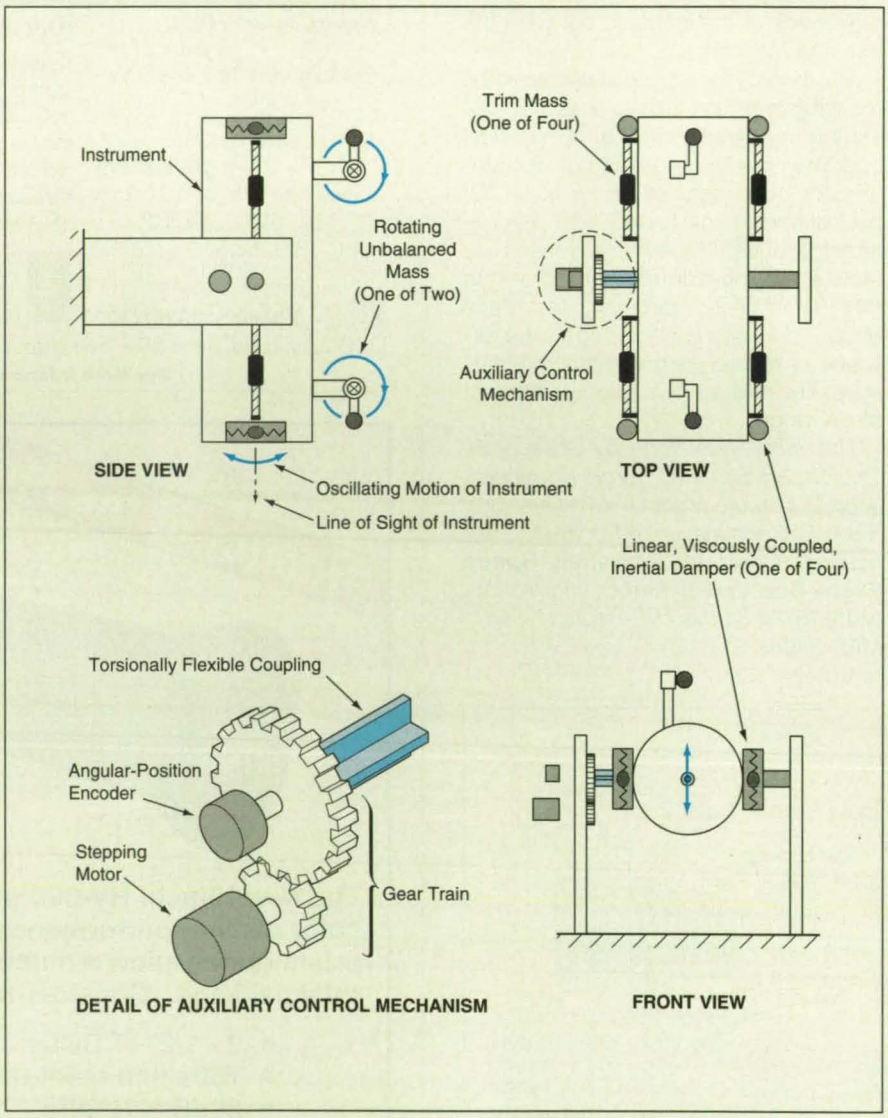
Improved auxiliary control mechanisms for rotating-unbalanced-mass (RUM) actuators have been proposed. A RUM actuator is a proposed device that would be mounted on a gimbaled, pivoted, or freely floating instrument and used to make the instrument oscillate about one or more axes. A RUM actuator would include one or more (typically, two) unbalanced masses (e.g., lump masses on arms) for each axis about which oscillation is desired. The unbalanced masses would be driven to rotate at constant angular velocity to produce oscillating centrifugal forces, which, in turn, would exert cyclic torques that make the instrument oscillate about the desired axis. RUM actuators could be used in both terrestrial and spacecraft applications: for example, to oscillate instruments as diverse as x-ray telescopes, magnetometers, accelerometers, and agricultural spraying nozzles in a variety of scan patterns that could include linear, circular, and raster.

An auxiliary control mechanism for a RUM actuator would serve to position and reposition the central coordinate about which the oscillating motion is produced. In the case of a line scan, it could be used to establish the midpoint of the line. In the case of a raster scan, it could produce the relatively slow motion along one raster axis while the RUM actuator would produce the faster oscillating motion along the perpendicular raster axis.

The figure illustrates schematically an instrument equipped with a RUM actuator for oscillation about a single axis to produce a line scan, plus a simple auxiliary control mechanism of the proposed type. The basic components of the auxiliary control mechanism would be a stepping motor, a speed-reducing (torque-increasing) gear train, and an angular-position encoder. The stator of the stepping motor would be mounted on a stationary supporting structure, while the motor would be connected to the low-torque input shaft of the gear train.

The high-torque output shaft of the gear train would lie on the axis about which the instrument is to be oscillated and would be connected to the instrument via a torsionally flexible coupling. The encoder would monitor the angular position of the high-torque shaft. Driven by the RUM actuator, the instrument would oscillate torsionally, via the flexible coupling, about the angular position of the high-torque shaft. The holding torque of the stepping motor, amplified by the gear train, would suffice to prevent the high-torque shaft from slipping out of the commanded center-of-scan position.

In a preferred version, the torsional stiffness of the flexible coupling would be chosen so that the resonant frequency of torsional oscillation of the instrument would equal the derived scanning frequency. Adjustable trim masses could be added to enable tuning to resonance and dampers could be added for stability. The resonance would amplify the effect of the RUM actuator (the dampers would reduce the amplification effect somewhat) so that the same scanning motion could be



The **Proposed Auxiliary Control Mechanism** would make it possible to design a smaller, cheaper, more energy efficient rotating-unbalanced-mass actuator.

achieved with smaller unbalanced masses. With smaller masses, the RUM actuator would consume less power: numerical examples from representative design cases suggest that RUM actuators equipped with auxiliary control mechanisms of this type could consume less power than do equally capable RUM actuators of older design, and as little as 1/100 the power of scanning mechanisms based on gimbal torque actuators.

The proposed auxiliary control mechanism as described thus far could be operated manually, in a quasi-open-loop fashion: A human operator would monitor the angular position of the high-torque shaft and issue step commands until the desired center-of-scan position was attained. No further adjustment or monitoring would be needed until it would be necessary to establish a different center-of-scan position. Alternatively, the stepping motor could be operated under angular-position-feedback control.

In comparison with previously designed RUM auxiliary control mechanisms, the proposed RUM auxiliary control mechanisms would be simpler and cheaper. They would be particularly suited for applications in which it is permissible to sacrifice some scanning precision for the sake of reducing weight, cost, and power consumption. In some cases, the reduction in power demand may make it feasible to use small batteries or solar cells as the sources of power.

This work was done by Michael E. Polites and Dean C. Alhorn of **Marshall Space Flight Center.** *For further information,* ***write in 8*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28817.

Universal Controller for Supersonic Engine Inlet

Engine-demand airflow is used as the primary control parameter.

Ames Research Center, Moffett Field, California

In a developmental method of controlling the variable air inlet of an engine in an advanced supersonic airplane, engine-demand airflow is used as the primary control parameter. In general, the optimum inlet angle depends on such other variables as the mach number, altitude, and ambient temperature. The optimum inlet angle as a function of these variables can be approximated by a schedule (the "inlet ramp schedule") of digitized values that can be implemented by a digital control system.

Research shows that the inlet ramp schedules of different engines that could be installed in the same supersonic airplane can all be corrected with engine-demand airflow. More specifically, the research shows that the optimum inlet angle depends primarily on the engine-demand airflow and is good for all altitudes and ambient temperatures. Thus, one can develop a simple inlet ramp schedule of inlet angle as a function of engine-demand airflow. This approach offers the following advantages:

- The design and installation of upgraded engines require few or no changes in the hardware and software of air-inlet controllers.
- Fewer air-inlet controllers are needed in the field.
- The probability of installing the wrong air-inlet controller is reduced.
- The maintainability and supportability of the airplane is enhanced.

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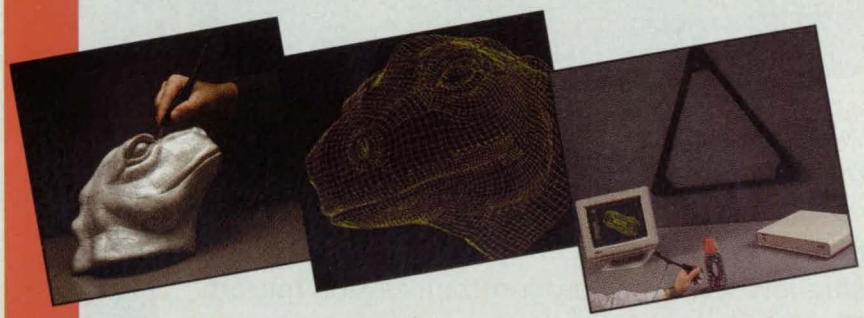

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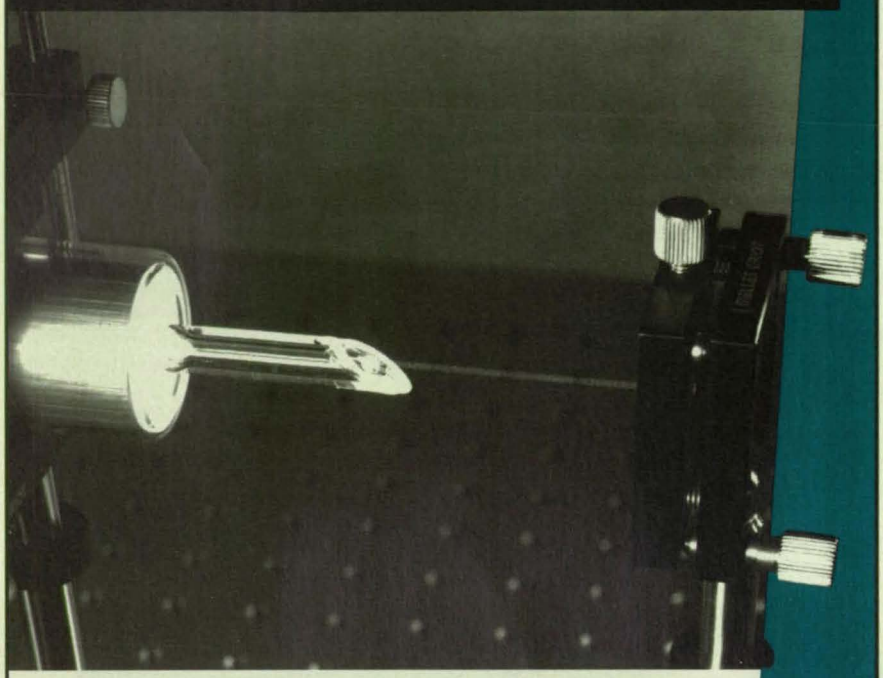

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This work was done by William A. Yonke, Daniel L. Robben, and Steve G. Nobbs of McDonnell Douglas Corp. for **Ames Research Center**. *For further information,* ***write in 49*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13193.

Special-Purpose Robotic Welder

Cooling bars presented a unique design problem.

Marshall Space Flight Center, Alabama

A robotic-welding apparatus has been developed for use in repairing the main combustion chamber of a rocket engine. Despite its special purpose, this apparatus has design features that would be beneficial in other robotic-welding applications; for example, the manufacture and repair of pressure vessels, chemical-processing vessels, and the like.

In the rocket-engine application, cracks and pinholes in the hot surface of the chamber are welded closed. During the welding process, copper bars are used to cool the area around the pool of molten metal. It was difficult to design brackets to support the robot arm, the robotic end effector with the welding torch, a wire feed-guide and manipulator, a camera, and positioning hardware so that none of these components would collide with or interfere with the cooling hardware. This design problem was solved by iterative application of computer-aided design techniques.

Each of the primary components of the apparatus is electrically insulated from the others by use of fiberglass brackets. The wire-feed guide is mounted at an angle to a micrometer-slide positioner to provide accurate, repeatable placement of the wire-feed guide with respect to the torch. The camera is also mounted at an angle to the positioner. The angles are necessary to provide adequate visual access to the weld pool during operation.

This work was done by David C. McFerrin, J. Ben Coby, Jr., Kenneth J. Gangl, David S. Hoffman, and Sidney G. Dawson of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 56*** *on the TSP Request Card. MFS-30020*

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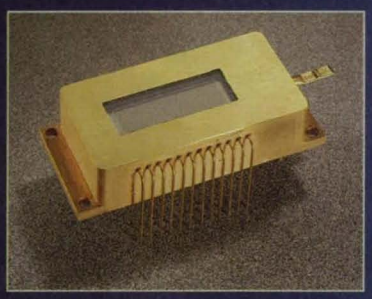

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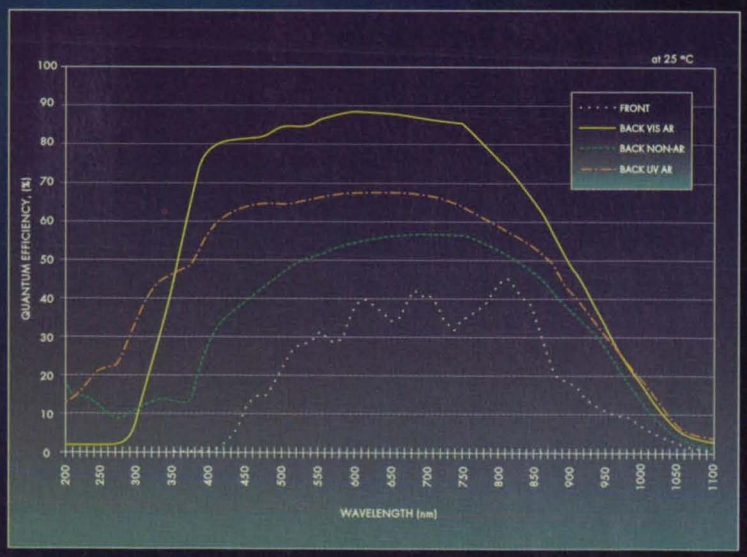

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6a Fiber-Powered Electronic Sensors
8a A High-Power Pulsed Ultraviolet Laser System
8a Ho:Tm:$Lu_3Al_5O_{12}$ as an Infrared-Laser Material
12a Ultraviolet Source for Testing Hydrogen-Fire Detectors
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FEATURES

3a Moving Closer to the Sun's Power
The Omega laser at the University of Rochester

DEPARTMENTS

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19a New Literature
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On the cover:
Engineers at the Chemical Vapor Deposition Facility at NASA's Langley Research Center use lasers to test the effects of heating on the flow of gas through a chemical vapor deposition reactor. The reactor, from the University of Virginia, is used to grow crystals for such uses as laser diodes. *Photo courtesy of NASA Langley Research Center*

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EDITORIAL NOTEBOOK

News of the Industry and Federal Labs

• Uniphase Corp., a San Jose, CA, manufacturer of HeNe, argon-ion, and diode lasers, acquired United Technologies Photonics (Bloomfield, CT), a division of United Technologies that supplies the cable television and long-haul telecommunications industries with integrated lithium niobate optical modulators for digital transmission of light signals through fiber optic cable. According to Kevin Kalkhoven, Uniphase's president and CEO, the company aims to repeat its success with the 1992 subsidiary Ultrapointe Corp., maker of a 3D imaging system for microcircuit defect detection and analysis. The new subsidiary will retain its acronym–it becomes Uniphase Telecommunications Products–as well as its location and current management. Among the latter is Vice President and Chief Technical Officer Fred Leonberger, who points to UTP's technological edge in its external modulation design and the advantage its waveguide technology will lend to Uniphase's developmental program in solid-state blue-emitting lasers.

• Optical Research Associates (Pasadena, CA) received NASA's Public Service Group Achievement Award, the only nongovernmental independent entity to be honored this year. The company was recognized for the role its Code V optical design software and engineering services played in the Hubble Space Telescope repair mission. The award certificate, signed by NASA Administrator Daniel S. Goldin, cites "outstanding contributions" in support of the Jet Propulsion Laboratory and NASA space exploration missions.

• SpecTran Corp. (Sturbridge, MA) announced completion of its purhcase of Applied Photonic Devices (Danielson, CT), a privately owned manufacturer of high-performance fiber optic cable. Raymond E. Jaeger, SpecTran's president and CEO, commented that the APD acquisition furthers "our long-term strategy to...diversify the optical fiber-based products we manufacture."

• Laser Science Inc. (Newton, MA) has delivered a unique laser system for measuring atmospheric trace gases to the National Institute for Environmental Studies (NIES), a division of the Japanese Environmental Agency. The instrument is based on a pair of CO_2 lasers that will aim their pulses at a mirror located on a satellite, which will return signals for collection and analysis. The mirror will be attached to the Advanced Earth Observing Satellite, to be launched by the Japanese government early next year. Laser Science organized the engineering team to deliver and assemble the system.

• The Center for Optics Manufacturing (Rochester, NY) has been granted $3 million by the Department of Defense to continue work in cooperation with its industry membership in advancing precision optics manufacturing technology. The American Precision Optics Manufacturers Association founded the Center in 1990 to develop computer-automated lens-making machinery to bolster US competitiveness in optics fabrication and thus halt the erosion of the domestic manufacturing base.

• Laser Photonics (Orlando, FL), recently acquired by Helionetics Inc. (Irvine, CA), is to absorb Helionetics' AccuLase medical subsidiary, the parent company announced. The move will bring under the Laser Photonics scientific/medical umbrella AccuLase's excimer-laser and proprietary fiber-optic-catheter technology, currently employed in laser angioplasty and transmyocardial revascularization. Steve Qualls, Laser Photonics' COO, noted that AccuLase has limited manufacturing capability, but that Laser Photonics is "an approved GMP medical laser manufacturer with excess production capacity."

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MOVING CLOSER TO THE SUN'S POWER

The Omega laser at Rochester's Laboratory for Laser Energetics steps out front in the quest for fusion energy.

In June the Laboratory for Laser Energetics (LLE) at the University of Rochester took a commanding position in the nation's effort to harness the process that powers the Sun and stars for a reliable energy source on Earth. When the newly revamped Omega went on line, it became the world's most powerful ultraviolet laser and a key resource in inertial confinement fusion research, the avenue scientists hope will lead to a novel and virtually inexhaustible supply of power for the future.

The $61-million Omega, funded by the Department of Energy, puts Rochester at the forefront of the effort at direct-drive fusion, in which lasers directly illuminate, heat, and compress isotopes of hydrogen to generate energy. This new system enables scientists to study more closely than ever before the conditions needed to ignite and sustain a fusion reaction, and is expected to be an important precursor of the National Ignition Facility (NIF), scheduled to be completed later this decade (see *Laser Tech Briefs*, April 1995, page 6a). A joint project of scientists at Rochester, Lawrence Livermore, Sandia, and Los Alamos laboratories, the NIF will be the biggest laser fusion machine ever built. The Department of Energy has designated Livermore as the preferred site for NIF and is seeking funds to begin construction next year.

The Omega system is a 30-kJ pulsed Nd:glass laser emitting a frequency-tripled beam at 351 nm. In boosting the football-field-sized Omega to its present capacity, engineers increased its energy output by a factor of 25, making it the world's most powerful ultraviolet fusion laser. It exceeds the present capacity of Livermore's indirect-drive Nova system, whose beams are converted to x-rays before hitting the target. But though it was designed primarily for direct-drive experiments, research with Omega is expected to help physicists understand phenomena of both methods. And since DOE has designated LLE the National Laser Users' Facility, scientists from all over the country will be able to use it to conduct high-energy laser experiments.

In direct-drive fusion research, Omega will be used to explore target physics at near-ignition conditions, with ion temperatures in excess of 2-3 keV and fuel density/radius products of more than about 2 g/cm^2; to investigate the hydrodynamics of energy-scaled high-performance targets; and to perform laser-plasma interaction experiments relevant to direct-drive target implosions.

Hotter than the Sun

After the laser creates it, Omega's beam is amplified and expanded many times, travelling a total of more than 500 feet and splitting into 60 beams before reaching the target. Housing the hydrogen target is an aluminum chamber 11 feet in diameter, with ports for several diagnostic instruments as well as for the beams, which are reflected by mirrors around the structure into the chamber. Each of Omega's beams is aimed to hit a specified section of the target with an accuracy of within 25 microns.

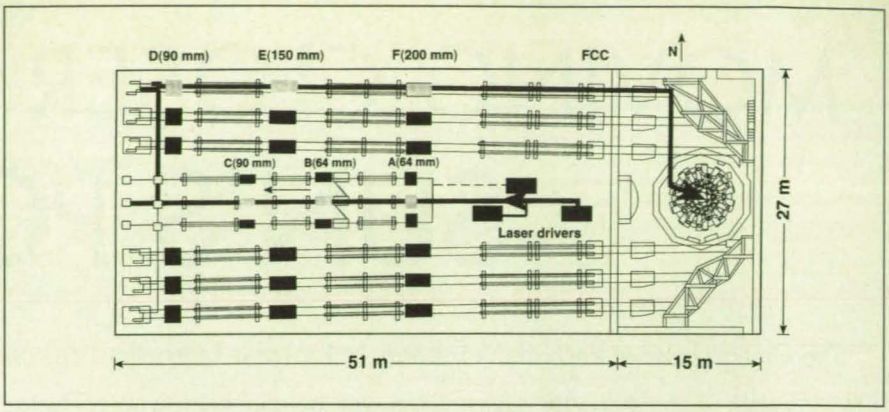
In the target chamber, the beams converge on a plastic or glass cylinder less than a millimeter wide filled with deuterium and tritium, two isotopes of hydrogen. The beams ablate the target's shell and implode the thermonuclear fuel to obtain pressures and temperatures high enough to fuse the isotopes.

Inside the chamber, temperatures can

The Omega laser driver line and injection optics along with portions of the laser system are seen in a view looking southwest in the laser bay.

reach up to 50 million °C, hotter than the inside of the Sun. Because of such elevated temperatures, Omega's glass, mirrors, and lenses need some time to cool down between shots. Therefore the laser can be operated just once per hour.

As the atoms of the target fuel fuse, they give off energy in the form of neutrons, which can be used to generate electricity. But for fusion to be useful as an energy source, it must reach what researchers call "scientific breakeven:" that is, the energy to emerge from the fusion reaction must be greater than what is needed to create it.



The Omega upgrade is an image-relayed system with three laser drivers, six amplification stages, and frequency conversion. Ninety-seven percent of beam energy is furnished by the last three amplifiers.

Two Decades of Advances

LLE's credentials for reaching the goal of inertial confinement fusion are many. As long ago as 1976, LLE's materials group led the development of high-gain, low-index-of-refraction phosphate laser glass for Nd:glass laser systems. In 1980, LLE scientists developed a method of converting Omega's laser light from the infrared to the ultraviolet, which is absorbed more efficiently by a pellet of fuel. Called polarization mismatch, this blue-light conversion method has since been adopted by all high-power solid-state ICF programs in the world. According to Stephen Jacobs of LLE, polarization mismatch has increased the effectiveness of Omega as a fusion driver by a factor of ten. LLE engineers completed conversion of the Omega to 351-nm operation in 1985.

In 1989, LLE announced its pioneering beam-smoothing technique to produce more uniform beam profiles for its frequency-tripled laser systems. Called smoothing by spectral dispersion (SSD), the method reduced the variations in illumination of a pellet from 30 percent down to just a few percent. SSD has since been implemented on Lawrence Livermore's Nova laser.

Reaching Out to Industry

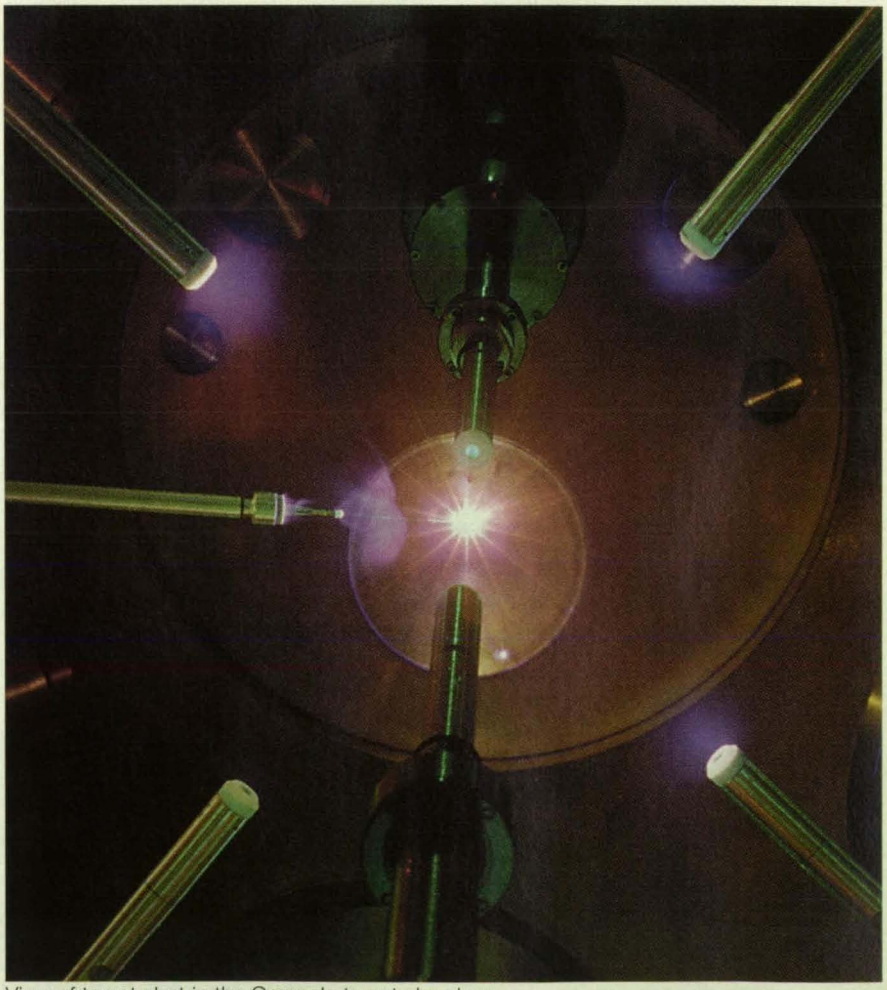
As part of the University of Rochester's outreach program, LLE has collaborated with industry and government in technology development. Companies which have contributed resources include the Empire State Electric Research Corp., Exxon Research and Engineering Co., Clark/MXR, Spectra-Physics, Rochester Gas and Electric, General Electric, and Standard Oil Co. In addition to DOE support, the New York State Energy Research and Development Authority has contributed important backing.

LLE scientists hold more than 63 patents in such fields as laser amplifiers, active mirrors, fusion target fabrication and coating, ultrafast switching, x-ray lithography, and liquid crystal devices. The laboratory has issued 14 licenses for the use of these patents in producing commercial products.

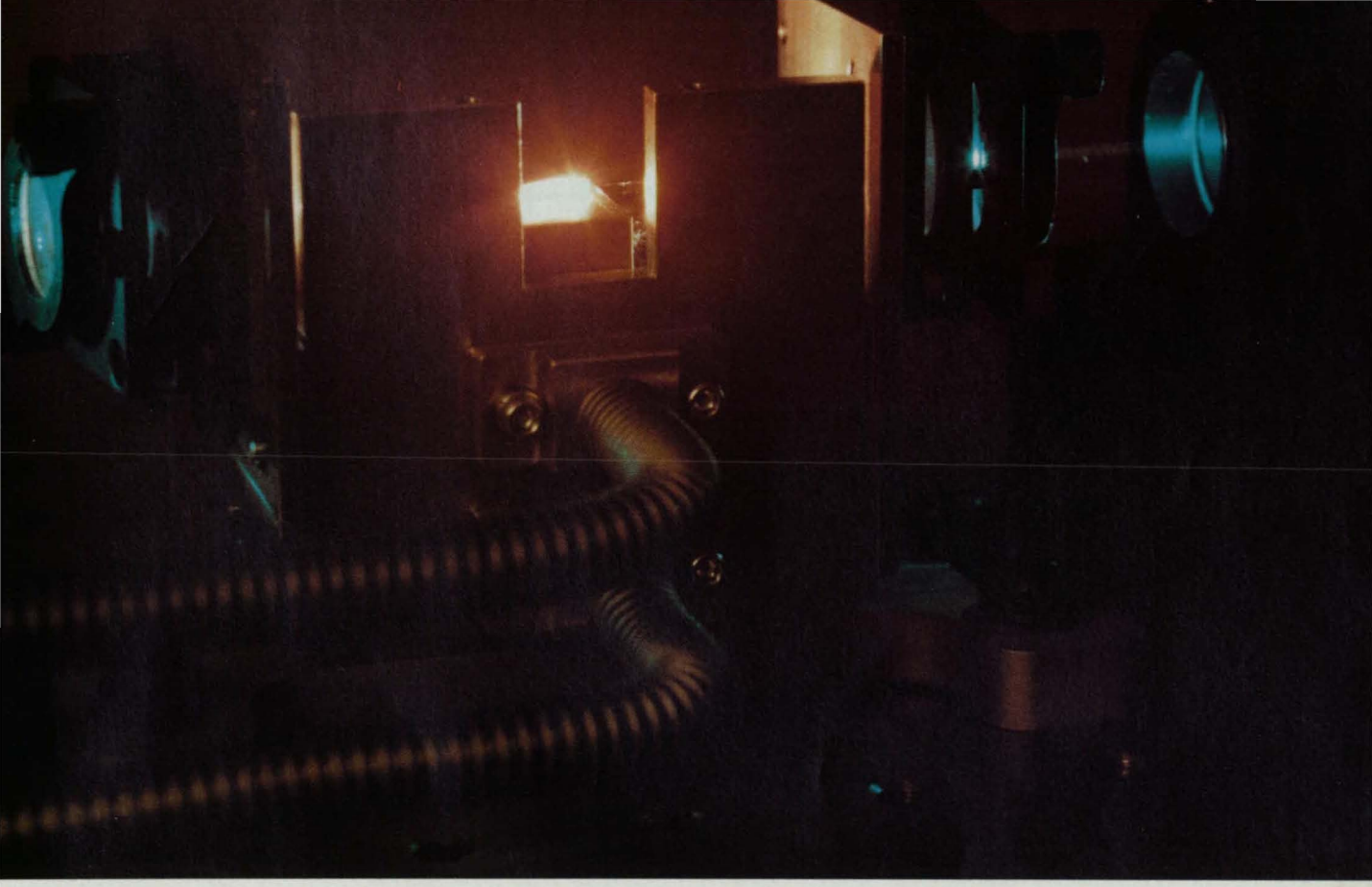
As the National Laser Users' Facility, LLE provides researchers with unique capabilities for experiments in high-energy-density physics, as well as such other areas as plasma physics, x-ray laser physics, extreme ultraviolet spectroscopy, and instrumentation development. Laboratory staff includes 191 professional, technical, and administrative personnel, and more than 100 graduate and undergraduate students from the university's optics, physics, and engineering departments participate in LLE programs.

Hailing the Omega upgrade, Victor H. Reis, Assistant Secretary for Defense Programs at the Department of Energy, called it "a highly flexible world-class laser that will serve the inertial fusion program well for many years....The laser was on time and on budget. The department is proud of this, the newest of our facilities."

LTB



View of target shot in the Omega's target chamber.



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Fiber-Powered Electronic Sensors

New sensor circuit provides an alternative to fiber-based sensors in some applications.

EG&G Energy Measurements, Los Alamos Operations, Los Alamos, New Mexico

Electronic sensors powered by fiber optics may be a low-cost off-the-shelf alternative to fiber-based sensors in some applications. While using less expensive electronic equipment, the system has a totally fiber-based connection between a sensor and a data-recording device, offering electrical isolation between the sensor and the station receiving the data. This greatly reduces the introduction of potentially damaging noise spikes into sensitive circuitry. The availability of low-power integrated circuits developed for the cellular telephone and laptop computer markets helped make this possible, but the introduction of high-efficiency gallium arsenide photovoltaic converters made it practical.

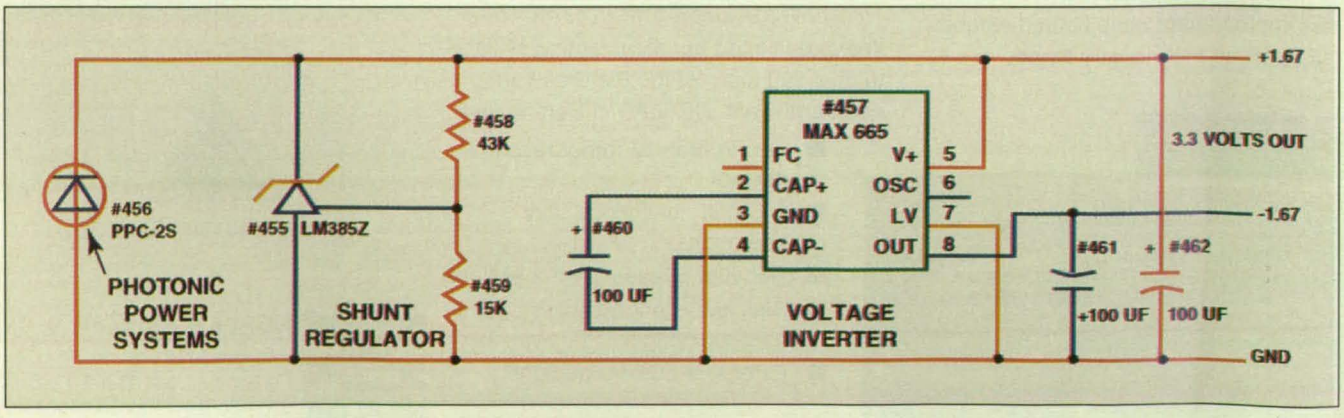
Researchers at EG&G Energy Measurements' Los Alamos Operations--a Department of Energy contractor--are developing the fiber-powered electronic sensors. Their circuits are powered by light from a fiber optic cable connected to a small laser. The circuit will deliver the desired 3.3 V at 10 mA to a low-power data acquisition circuit. The total conversion efficiency is 40% at this time. Instead of using a boost-topology switcher to step up 2 V to 3.3 V, in laboratory tests a shunt regulator followed by a voltage doubler proved superior. The startup currents of the boost-topology switcher were very high, causing startup failure at heavy loads. Also, the efficiency of the switcher was about 83% compared with about 95% for the voltage-doubler circuit.

Noise is a major design consideration at low operating voltages. Noise spikes from the boost-topology switcher's inductor were being coupled into the A/D circuitry, but the voltage doubler did not produce spikes, and its ramp-shaped ripple (as compared with a spike) was easy to filter.

The photovoltaic converter is shunt-regulated at 1.65 V, which is very close to the optimum power-out point of the V-I output characteristic curve for this 2-V (open circuit voltage) converter. If it was replaced by the 6-V version of the converter and linearly regulated to 5 V, or stepped down with a buck-topology switcher, the resulting circuit would not operate at the optimal power point of the 6-V version's V-I curve for the output current target of 10 mA; the 6-V part has a higher internal impedance. The circuit was used to power a Motorola 68HC05 central processing unit (CPU) connected to an Analog Devices AD7714 A/D converter and driving a Brown Boveri fiber-coupled light-emitting diode with the data from the CPU UART. The circuit draws 4 mA at 3.3 V, running at a CPU clock rate of 2.4 MHz and a rate of 9600 baud. Up to 6 mA of current can be allocated to power the sensors feeding the A/D and still remain within the bounds of the 10-mA current budget.

This technology could benefit the automotive industry by reducing ignition noise during tests, and the electrical power industry by allowing experiments and testing in high-voltage areas. In medicine, it would be a way to isolate patients from wall current and thus from both electrical interference and the potential dangers of equipment failure.

This work is being done by Noor Khalsa and Ron Ramsey at **EG&G Energy Measurements' Los Alamos Operations**. *For more information, contact Bruce Whitcomb, Director of EG&G Energy Measurements' Office of Research and Technology Applications, at (702) 295-3164. Inquiries may also be addressed to EG&G Energy Measurements, PO Box 1912, Las Vegas, NV 89125.*



Circuit diagram for the **fiber-powered electronic sensor.**

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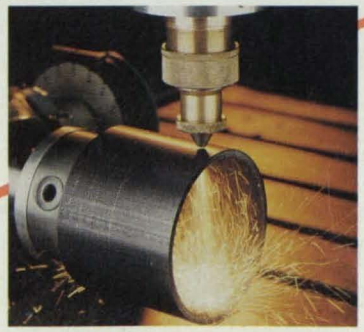

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A High-Power Pulsed Ultraviolet Laser System

Ultraminiature Q-switched solid-state lasers have switching and analysis applications.

AlliedSignal Aerospace, Kansas City Division, Kansas City, Missouri

The Laser and Electro-optical Engineering Group at the AlliedSignal Kansas City Plant, operated for the US Department of Energy (DOE), has combined its solid-state laser technology with frequency-conversion technology to develop laser systems for switching high-voltage electronics. The application shows promise in laser spectroscopy. The compact, rugged lasers are designed to survive and operate in extreme mechanical and thermal environments.

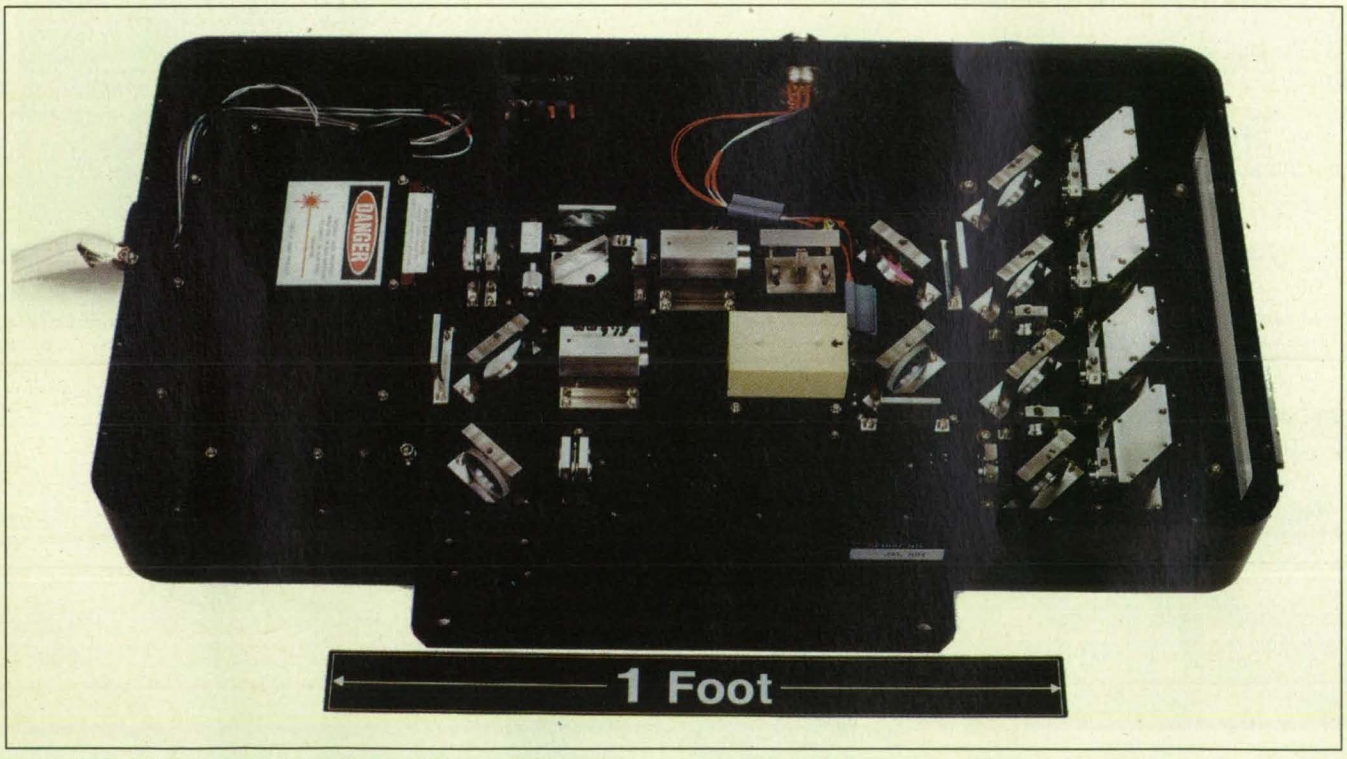
The group has developed a UV laser source with eight simultaneous channels. The system, built around their compact laser (less than 50 cu. in.) rated at 700 mJ per pulse (10 ns nominal), generates 100 mJ of UV laser light. The conversion efficiency is approximately 65 percent in the second harmonic (530 nm) and 35 percent in the fourth harmonic (265 nm). These results are accomplished with a highly multimode input, a fact that distinguishes it from performance reported in the literature by others. The optical system's volume is 475 cu. in. The design also includes a custom thermoelectric cooler for the KD*P doubling crystal.

The laser pulses can be used for mega-volt/mega-amp switching networks with nanosecond timing resolution between multiple switches. At the other end of the application spectrum, the UV light can be used to ablate materials and determine the concentration of metals for contamination study in a variety of situations.

Applications examples include radioactive-species identification, real-time heavy metal contamination analysis of soils and building materials, and perhaps measurement of lead concentration in blood screening for schoolchildren. Extremely high-energy transmissions of light pulses through optical fiber in conjunction with this type of system have been proven. Other applications of this technology range from ordnance initiation systems to factory-environment manufacturing systems for laser welding, drilling, cutting, and power transmission.

This work was done at the **AlliedSignal Kansas City Plant**, *operated for the US Department of Energy under contract DE-AC04-76DP00613. For additional technical information, contact Jim Hendrix at (816) 997-3483.*

Inquiries concerning the availability of this technology should be addressed to Tom Davis in AlliedSignal's Office of Technology Transfer; (816) 997-5275.



A prototype of the compact **eight-channel UV laser system.**

Ho:Tm:$Lu_3Al_5O_{12}$ as an Infrared-Laser Material

This material was selected on the basis of quantum-mechanical modeling of lasing properties.

Langley Research Center, Hampton, Virginia

Lutetium aluminum garnet doped with holmium and thulium (Ho:Tm:$Lu_3Al_5O_{12}$, also called "Ho:Tm:LuAG") has been shown to be useful as a room-temperature infrared-laser material. This material was selected from among a number of candidate materials for the development of a laser that would operate at room temperature at a wavelength near 2.0 μm, but with an efficiency greater than the efficiencies of 2.0-μm room-temperature lasers based on Ho:Tm:$Y_3Al_5O_{12}$ ("Ho:Tm:YAG") and on Ho:Tm:$YLiF_4$ ("Ho:Tm:YLF"). Other desirable charac-

teristics for the candidate materials included compatibility with pumping by GaAlAs laser diodes at a wavelength in the vicinity of 0.8 μm, plus good thermal and mechanical properties.

The investigation of Ho:Tm:$Lu_3Al_5O_{12}$ and other candidate laser materials involved special attention to what was considered to be the greatest problem associated with room-temperature lasers at wavelengths near 2.0 μm; namely, high thresholds. A theoretical expression was developed to describe the lasing threshold of a material in terms of such parameters of the material as the thermal occupation of the lower laser level and the effective stimulated emission cross section. A sophisticated mathematical model based on quantum mechanics was used to evaluate these parameters. Then the threshold was evaluated for each laser material and the materials with low thresholds were considered to be desirable candidates.

Ho:Tm:$Lu_3Al_5O_{12}$ features relatively low thermal occupation of its lower laser level because this level is higher than are the corresponding levels of most of the other available laser materials. In addition, Ho:Tm:$Lu_3Al_5O_{12}$ has a reasonably large effective cross section for stimulated emission because of the contribution of several transitions around a central strong transition. A low threshold results from the combination of these properties, making the performance of this laser material potentially superior to those of other commercially available laser materials. While Ho is the element that participates in the main laser process, it does not absorb the pump radiation efficiently by itself. Tm is incorporated into the laser material to absorb the pump radiation and efficiently transfer the energy of that radiation to the Ho (see Figure 1).

Yet another desirable property of Ho:Tm:$Lu_3Al_5O_{12}$ is that its calculated rate of upconversion is lower than those of other laser materials like Ho:Tm:YAl_5O_{12} and Ho:Tm:$YLiF_4$. Inasmuch as upconversion detracts from the efficiency of a laser, this lower rate of upconversion is highly desirable. Finally, like other garnets, $Lu_3Al_5O_{12}$ has thermal and mechanical properties suitable for high performance in lasers.

An experimental Ho:Tm:$Lu_3Al_5O_{12}$ laser was constructed, pumped by a Ti:Al_2O_3 laser at a wavelength of 0.781 μm (to simulate pumping by a GaAlAs laser diode at about this wavelength). Fluorescence at room temperature in the wavelength range of 1.6 to 2.2 μm was observed, with a peak at 2.1 μm (see Figure 2). The efficiency of this laser was limited by the thinness of the

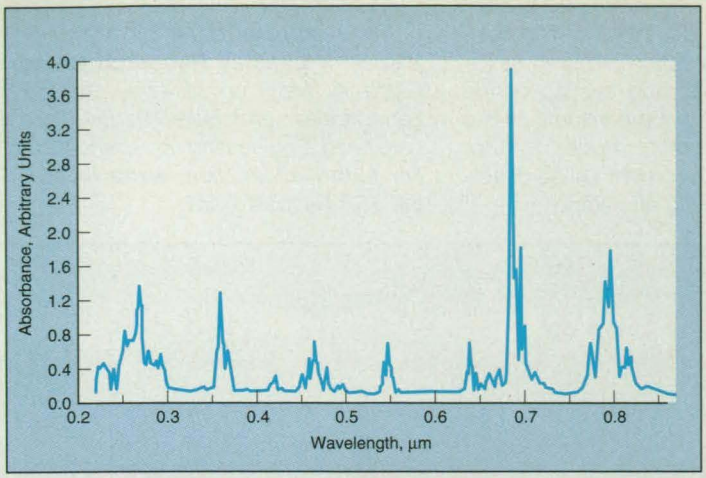
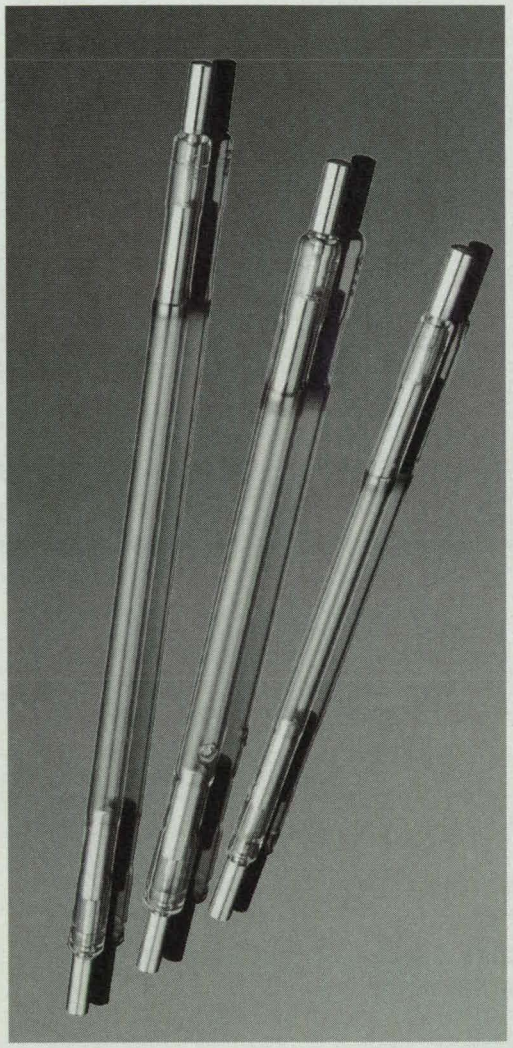


Figure 1. The **Absorption Spectrum** of Ho:Tm:$Lu_3Al_5O_{12}$ at a temperature of 300 K includes a peak at 0.78 μm that is attributed to Tm. Pumped energy at this wavelength can be absorbed and transferred efficiently to the Ho for lasing.



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Ho:Tm:$Lu_3Al_5O_{12}$ sample (with consequent limited absorption of pump radiation) and by the limited overlap of the pumped volume with the volume of the laser electromagnetic mode. Further research and development will be directed toward increasing efficiency.

This work was done by Norman P. Barnes of **Langley Research Center**, *Clyde A. Morrison of Army Research Laboratories, and Elizabeth D. Filer of Lockheed Engineering & Sciences Co. For further information,* ***write in 35*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center; (804) 864-9260. Refer to LAR-15105.

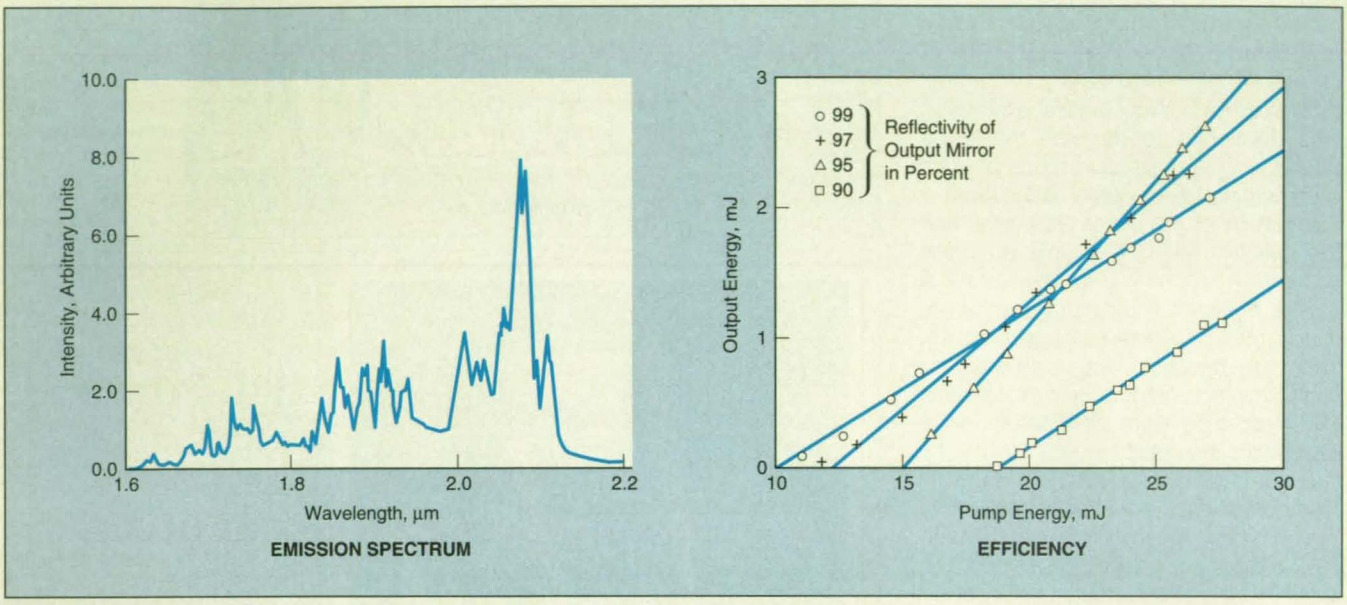

Figure 2. The **Emission Spectrum** of an experimental Ho:Tm:YAl_2O_5 laser includes a laser peak at a wavelength of about 2.1 μm. The efficiency plot shows relatively low efficiency, but future improvements are expected.

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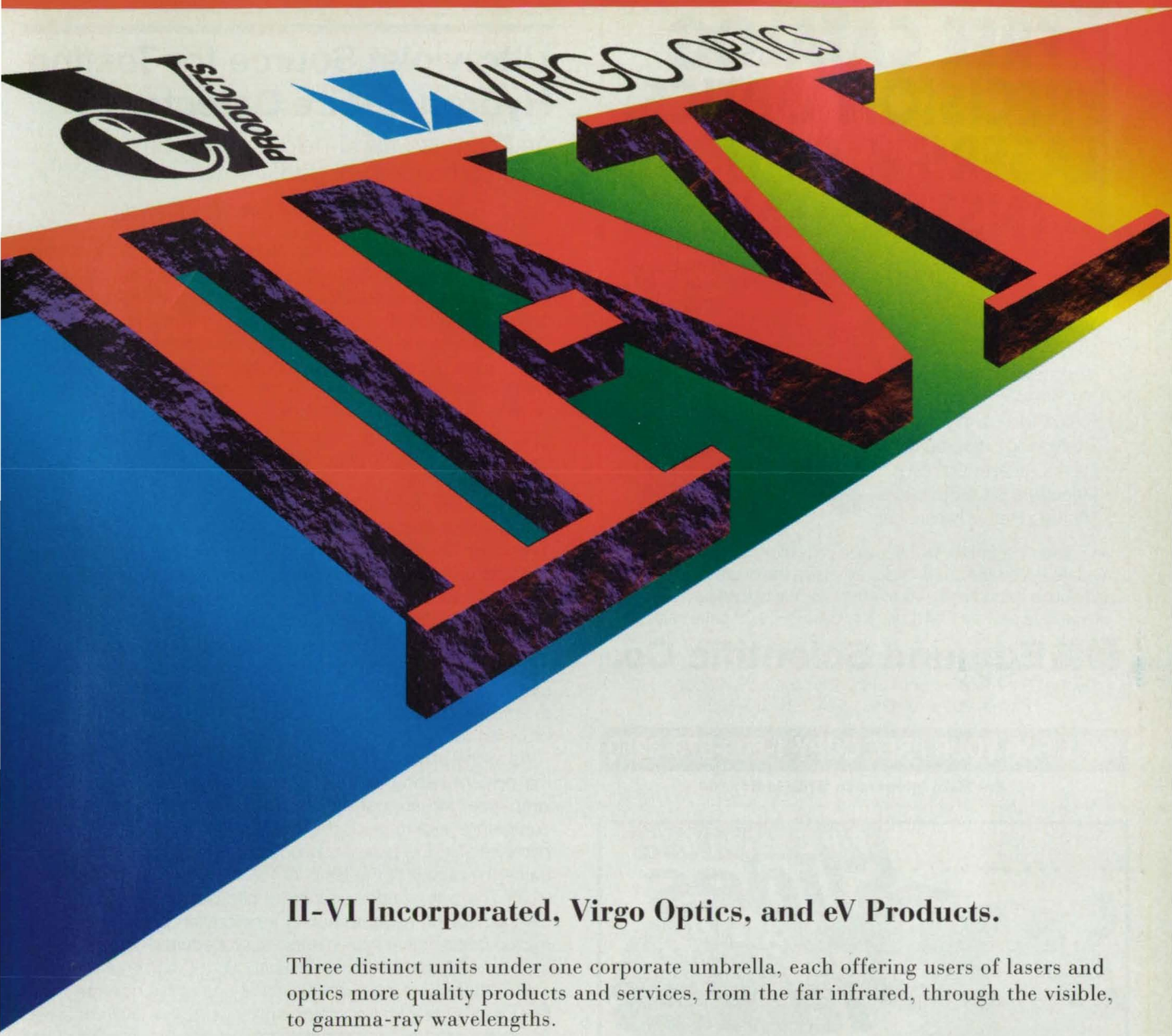

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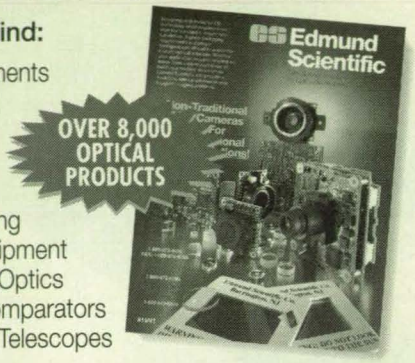

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Ultraviolet Source for Testing Hydrogen-Fire Detectors

An improved hand-held unit can be adjusted and calibrated.

John F. Kennedy Space Center, Florida

A hand-held portable unit emits ultraviolet light similar to that emitted by hydrogen burning in air. The unit was developed for use in testing optoelectronic hydrogen-fire detectors, which respond to ultraviolet light at wavelengths from 180 to 240 nm. This wavelength range is unique in that within it, hydrogen fires emit small but detectable amounts of radiation, light from incandescent lamps and the Sun is almost completely absent, and air is sufficiently transmissive to enable detection of a hydrogen fire from a distance. Consequently, this spectral region is favorable for detecting hydrogen fires while minimizing false alarms.

In operation, the hand-held unit is aimed toward a hydrogen-fire detector from a prescribed distance and direction and turned on to simulate a hydrogen fire. The hand-held unit replaces an ultraviolet flashlight that was previously used to test hydrogen-fire detectors of three different levels of sensitivity at various distances and was powerful enough to trigger alarms in the least sensitive units at the maximum distance of 54 ft. (≈16 m). However, the flashlight was much too powerful for testing more sensitive units at smaller distances, and there was no way to adjust the intensity of its ultraviolet output. There was also no provision for calibration of the ultraviolet output.

As in the ultraviolet flashlight, the source of ultraviolet light in the present hand-held unit is a krypton discharge lamp. This lamp was chosen, not only because its ultraviolet spectrum is compatible with that of the hydrogen-fire detectors but also because of its low power consumption. A sapphire lens concentrates the output of the lamp into a beam with a divergence of ≈10°. The unit includes an internal photodetector that monitors the intensity of the lamp during a calibration procedure, and a microprocessor that implements the procedure. The unit is powered by a 9-V battery, which lasts about 100 on/off test cycles.

The intensity of the output is set at one of five discrete levels by use of a disk that contains openings of five different sizes: the disk is rotated to place the desired opening in front of the lamp. The disk can also be rotated to a sixth position with no opening for calibration. A spring-loaded set screw and a small detent hold the disk at each position. To operate the unit, the user turns the disk to the appropriate setting and presses an "on" button. If the battery voltage is adequate, a green light-emitting diode flashes, indicating that it is all right to proceed to test a hydrogen-fire detector.

To initiate a calibration procedure, the user rotates the disk to the calibration position, in which there is no opening between the lamp and the outside world. When the disk is in this position, a small hole inside the disk allows light to travel to an optical interrupter, which responds by sending a signal that indicates to the microprocessor that calibration has been requested. In this configuration, pressing the "on" button causes the control circuitry in the unit to turn the lamp on and off, monitor the intensity of the output, and modify the current supplied to the lamp to lock set the intensity at a determined level. The signal for setting the current is saved in a memory circuit and used to set the current until another calibration is requested. This approach to calibration is based partly on the assumption that the intensity of the output will not drift during an interval of a few hours. Thus far, tests have validated this assumption.

This work was done by Gregory A. Hall and William E. Larson

of **Kennedy Space Center** *and Robert C. Youngquist, John S. Moerk, William D. Haskell, Robert B. Cox, Jimmy D. Polk, Stephen J. Stout, and James P. Strobel of I-NET. For further information,* ***write in 32*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-3017. Refer to KSC-11685.

Ammonia and Ethylene Optrodes for Research on Plant Growth

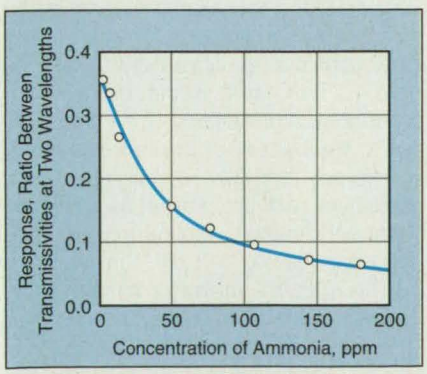
Low concentrations can be measured.

John F. Kennedy Space Center, Florida

Fiber-optic sensors are being developed for use in measuring concentrations of ammonia and ethylene near plants during experiments on the growth of the plants in enclosed environments. The roles of ethylene and ammonia in plant growth are not yet known, but it is known that plants emit these gases, and it has been conjectured that these gases either give rise to, or at least are associated with, environmental stresses on plants. The developmental fiber-optic sensors satisfy a need to measure concentrations as low as a few parts per billion (ppb) and are thus expected to contribute to research on the roles of ethylene and ammonia in the growth of plants.

Fiber-optic chemical sensors are also called "optrodes" and have been described in a number of previous articles in NASA Tech Briefs. An optrode typically includes a clear plastic lead-in optical fiber, a porous glass or polymeric sensing length of optical fiber with a chromophoric reagent sensitive to the analyte (the chemical to be detected) embedded in the glass or polymeric matrix, and a clear plastic lead-out optical fiber. The atmosphere containing the analyte permeates the pores, bringing the analyte into contact with the chromophoric reagent. The reaction between the analyte and the chromophoric agent changes the spectral characteristics of the sensing length of the fiber: in simplistic terms, it changes the color of the fiber by an amount proportional to the concentration of the analyte.

In the case of these particular optrodes, the spectral characteristic of interest is the ratio between the spectral transmissivities at two different wavelengths. Light from two light-emitting diodes at the two wavelengths is coupled through the lead-in fiber to the sensing length. After passing through the sensing length, the light travels along the lead-out optical fiber to photodetectors that mea-



The **Response of an Optrode** to the concentration of ammonia in water is fairly sensitive up to about 50 ppm.

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sure the remaining intensities, which can be used to calculate the ratio of interest and thus the concentration of the analyte.

Experimental ethylene-sensing optrodes have been made from porous glass optical fibers and found to be capable of indicating concentrations of ethylene as low as 50 ppb. Experimental ammonia-sensing optrodes have been made from a variety of plastic optical fibers and chromophoric reagents; these sensors have been demonstrated to respond to ammonia vapor at concentrations from a few ppb to 200 parts per million (ppm) and to ammonia dissolved in water (see figure) at concentrations from a few ppb to 50 ppm. Two additional and unique features observed in experiments on sensing of ammonia were independence of pH in the pH range from 1 to 13 and selective detection of dissolved ammonia in the presence of ammonium ions.

This work was done by Quan Zhou and Mary Beth Tabacco of Geo-Centers, Inc., for **Kennedy Space Center**. *For further information,* ***write in 46*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-3017. Refer to KSC-11624.

Laser Velocimeter for Use on Helicopter Rotor

An image-rotating optic would transform the laser beams to the rotating reference frame.

Ames Research Center, Moffett Field, California

A laser velocimeter is being developed to measure the flow of air in the vicinity of one of the blades of a helicopter rotor. The outstanding feature of this velocimeter would be an image-rotating optical subsystem that would transform the velocity-probing laser beams into the rotating reference frame from the stationary laboratory reference frame, in which the beams would be generated. Thus, the transformed beams would be stationary with respect to the rotor blade; this would enable the continuous monitoring of the velocity of flow at some point in the reference frame attached to the blade, provided that the blade did not vibrate.

The figure illustrates schematically the major optical components. The output of a laser would be divided by a beam splitter into two parallel beams, which would be steered by a stationary mirror onto a path coaxial with the rotor. On the way up toward the rotor, the beams would pass through an image-rotating optic, which could be a Dove prism, a Pechan prism, a folded Abbe prism, or a three-mirror device like the one in the figure. When an optic of this kind is rotated through an angle θ about the optical axis (which is also the axis of the helicopter rotor in this case), the image viewed through the optic rotates through an angle 2θ. The image-rotating optic would be made to rotate in synchronism with the rotor but at half the rotor speed. Thus, the beams emerging from the top of the image-rotating optic would be stationary with respect to the turning rotor.

The beams would travel up along the hollow rotor shaft to a focusing lens, which would make them intersect at a point that would define the center of the probe volume. A mirror would steer the intersecting beams to position the point of intersection at the desired height above the surface of the blade and at the desired horizontal coordinate downstream or upstream of the leading edge.

Light back-scattered from small particles (e.g., dust) entrained in the flow that passes through the probe volume would be focused by a Schmidt-Cassegrain collector into an optical fiber. The collector and fiber would be part of the rotating assembly. Using the optical analog of an electrical slipring, the other end of the fiber would be aligned along the axis of rotation, along which the light would be coupled out to the nonrotating laboratory reference frame. This light would contain the frequency information that can be related to the velocity of the light-scattering particles; the light signal would be detected and processed by standard laser-velocimeter circuitry and processing methods.

The system arranged as shown in the figure would be sensitive to velocity in the plane of the page along a line slightly tilted with respect to the axis of the rotor. A second coaxial dual-laser beam subsystem of different color

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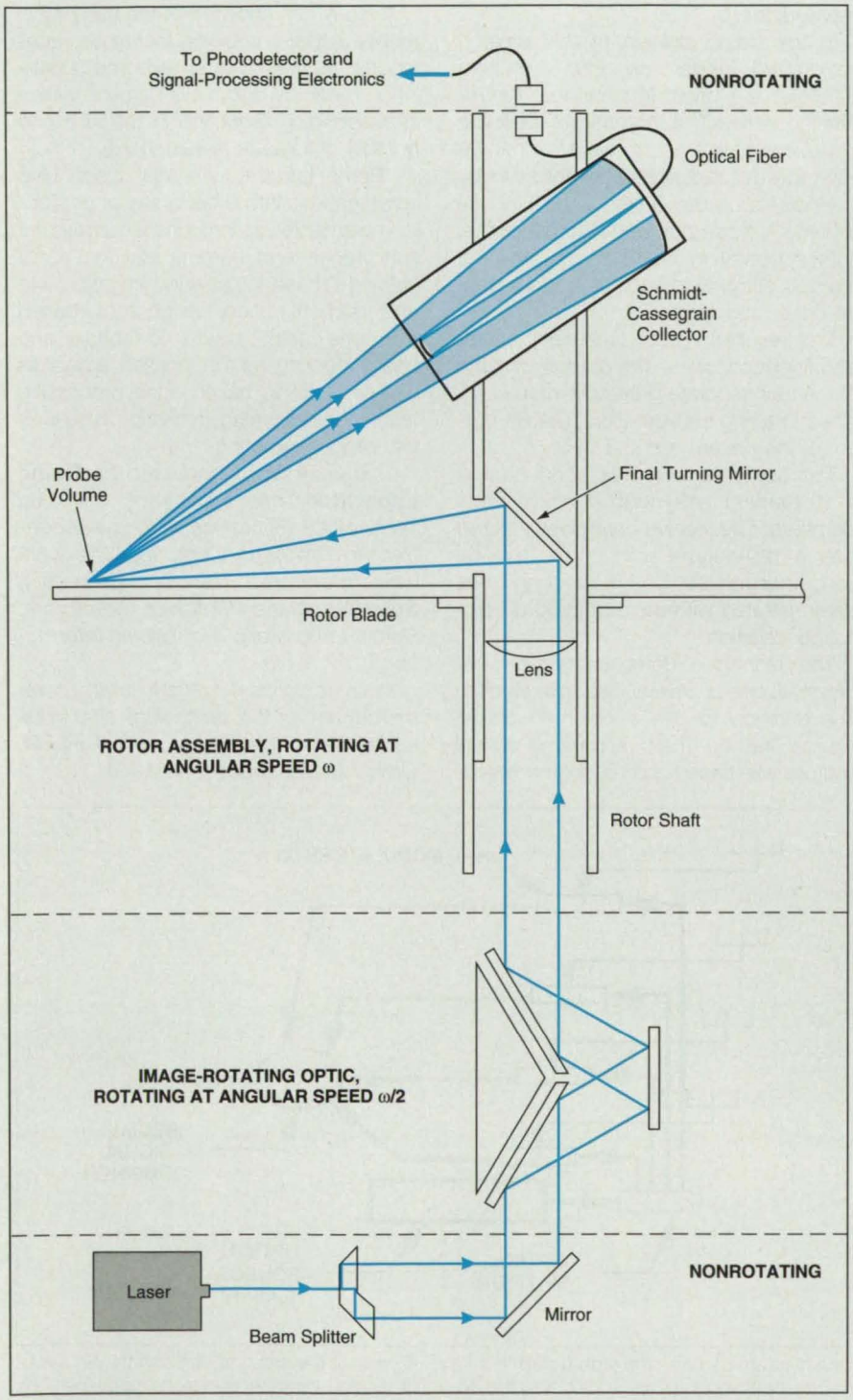
could be aimed at the same probe volume along the same bisector of the intersecting beams, but in a plane of intersection perpendicular to that of the first two beams; this would enable the simultaneous measurement of velocity along the horizontal direction running downstream or upstream of the leading or trailing edge. A third such subsystem of yet another color, aimed at the same probe volume from a final turning mirror at a different axial location, could enable the measurement of the third component of velocity, although this measurement would be coupled with the other two and would have to be uncoupled in processing.

This work was done by Stephen E. Dunagan of **Ames Research Center**. *For further information,* ***write in 24*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13106.



The **Laser Beams Would Be Transformed** by the image rotator, so that they would be stationary in the coordinate frame attached to the rotor blade.

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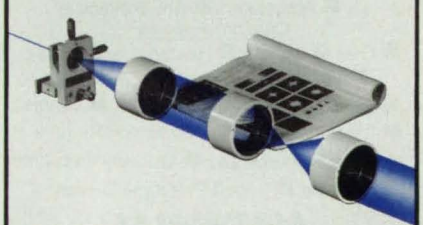

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A Photonically Based Receive Signal Combiner for RF Phased Arrays

The use of photonic implementation of a receive signal combiner in an RF phased-array antenna can reduce the weight of the antenna and provide several performance improvements.

Rome Laboratory, Photonics Center, Griffiss AFB, New York

Recent work has proven the advantage of implementing a receive signal combiner for an RF phased-array antenna in optical waveguides rather than in coaxial cable or pressurized RF waveguides.

In the demonstration of this project, conducted under an effort entitled "Microwave Optical Interconnect for RF Phased Arrays," a number of possible signal-combining efforts were examined. Here the slot radiators were followed by low-noise amplifiers (LNAs) and RF phase shifters. A diode-pumped Nd:YAG optical source operating at 1319 nm provided the optical signal to each of the four electro-optic modulators.

This resulted in four time-delay-equalized fiber optic links. The outputs of each of the four separate detectors were combined in a ring configuration. The RF output of the system is at 3.3 GHz.

The demonstration was conducted in a 16-element array with 4 active array elements. The receive beam was steered over a 120-degree scan angle. In addition, monopulse beam steering was demonstrated with more than 50 dB signal cancellation.

The technique demonstrated on this project is one of several that were studied. The decision to use a common optical source rather than separate optical sources was based upon concerns regarding coherence effects such as noise.

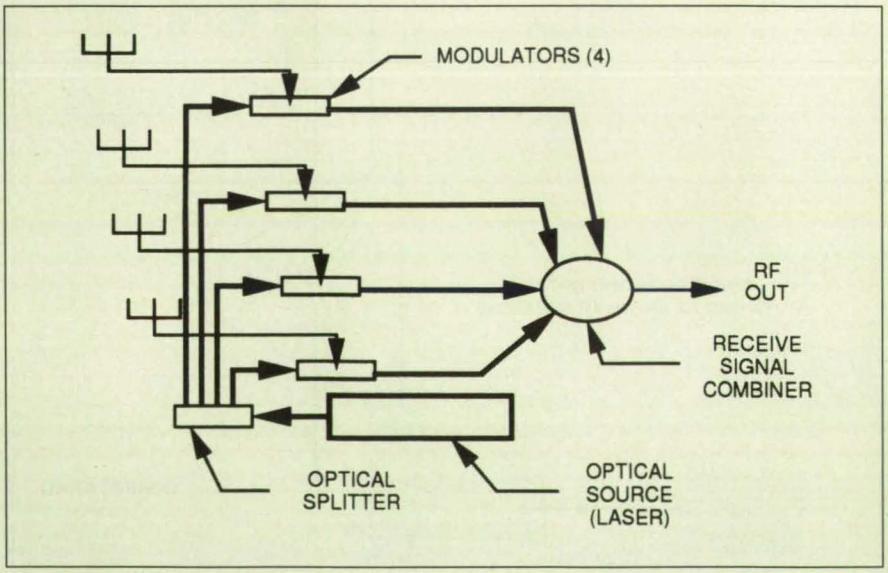
This photonic-based receive signal combining technique could be applied to subarrays rather than individual elements, as accomplished in this demonstration.

A study has shown that the use of this receive signal-combining technique could reduce the weight of an airborne surveillance radar by about 30 percent with a corresponding reduction in the size and number of fuselage penetrations.

Rome Laboratory is also continuing investigations into other areas of photonic implementation into phased arrays for surveillance and communications applications. These include investigation into and demonstration of photonic-based true-time delay beam formation and beam steering for RF phased arrays as well as photonic-based signal processing techniques and high-dynamic-range links for antenna remoting.

This work was conducted by **Rome Laboratory** *under contract to United Technology Photonics with a subcontract to Raytheon Company. The work was monitored by N. Bernstein, Surveillance and Photonics Directorate, Rome Laboratory. No further information is available.*

Inquiries concerning rights for the commercial use of this technology should be addressed to the Patent Counsel, RL/JA, Griffiss Air Force Base, NY 13441.



Line diagram showing the **signal path** from the RF input at the antenna, through the RF cable, electro-optic modulators, and fiber to the detectors located in the receive signal combiner. The RF output from the signal combiner then is sent to the signal processing equipment or receivers, depending upon the application.

A Microwave Tapped Delay-Line Filter Using High-Dispersion Fiber

Microwave filters based on the use of high-dispersion fiber are reconfigurable.

Rome Laboratory, Photonics Center, Griffiss Air Force Base, New York

Fiber-based lines have been a suggested method of time delay for several years. Such lines offer large bandwidths and wide dynamic range, all in a small package size. Several different methods have been demonstrated using fiber delay lines, most of which use several fixed lengths of fiber to achieve stepped time delay.

The method employed in the current example exploits fiber dispersion to achieve a variable time delay. By tuning the wavelength the relative time delay is changed. A 1-km length of high-dispersion fiber (-98ps/km-nm) has yielded approximately 5 ns of delay over a 50-nm tuning range.

Tapped delay-line filters are the weighted sum of several delayed versions of the same RF signal. Using the dispersion in fiber as the delay medium, it is possible to create a spectrum of RF delayed signals. In this idealized scheme, a broadband incoherent light source modulated with an RF signal would create this delay spectrum. Because of practical considerations, it is much easier to create a "sampled" broadband source by using several sources at various wavelengths. This comb of wavelengths can be weighted and summed to produce a more traditional transversal filter.

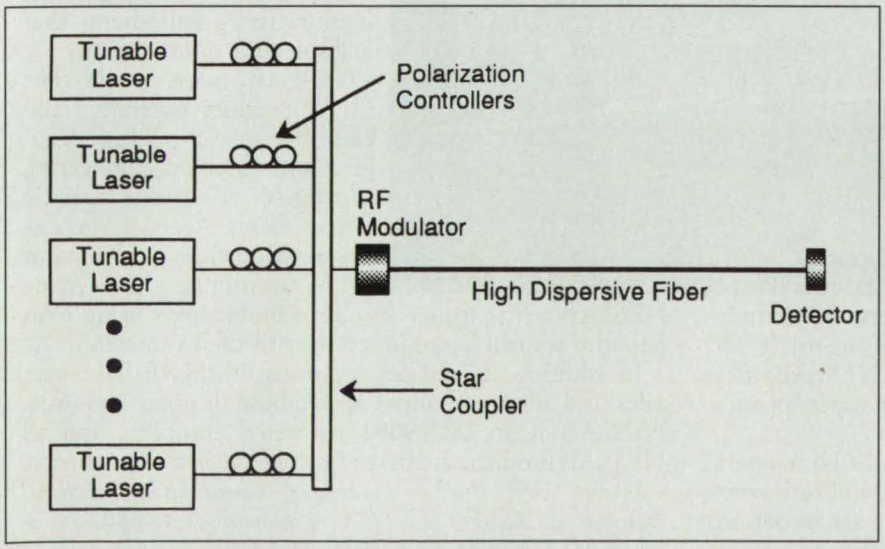
The configuration of the tapped delay-line filter is shown in the figure. This system uses 8 tunable laser diodes to form the 8 spaced time delays. The wavelength tunablity of the diodes allow a reconfigurable time separation between taps. The weighting of each tap is changed by varying the current sent to the particular diode. The 8 stepped wavelengths are combined by a star coupler and sent to a modulator. An external $LiNbO_3$ modulator is used to avoid any bulk time delays and to allow for high-frequency operation. The comb of wavelengths is then propagated through a 1-km length of high-dispersion fiber. The relative time delays seen between two adjacent taps is defined by

$$\Delta\tau = \Delta\lambda DL$$

where $\Delta\lambda$ is the wavelength difference between the two taps, D is the dispersion of the fiber, and L is the fiber length. In our system, tap spacing can be easily changed by varying the wavelength of each diode. This tunablity also implies that unequal tap spacing can be used, and work is continuing to explore its signal-processing implications.

This work was done by Douglas Norton and Steven Johns of the Air Force Photonics Center, Surveillance and Photonics Directorate, **Rome Laboratory**, *Griffiss AFB, New York. No further information is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, RL/JA, Griffiss AFB, NY 13441.



Reconfigurable Tapped Delay Line Filter is implemented using both wavelength- and amplitude-tunable laser diodes.

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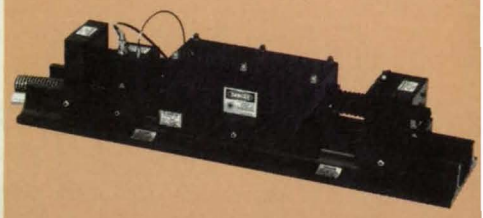

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II-VI Inc. has recently expanded its product line to include laser optics for wavelengths from the ultraviolet through the far infrared.

The recent acquisition of Virgo Optics of Port Richey, FL, has expanded the II-VI product line to include optical components for use in the spectrum from 190-3000 nm. Virgo Optics offers laser-gain materials such as Nd:YAG and Nd:YVO, as well as nonlinear crystals such as KNbO and BaTiO. Services provided by the Virgo Optics division include refurbishment of damaged laser crystals such as Nd:YAG and KTP. The Virgo division also offers custom coating, crystal fabrication, and wafer processing.

In addition to the recently acquired Virgo products and services, the II-VI product line includes a complete range of infrared products and services for industrial, commercial, medical, military, and research lasers covering the 2.0-to-20-micron range.

Recent II-VI new-product introductions include: **off-axis parabolic mirrors** for diffraction-limited performance; **ATFR beam delivery mirrors** to prevent unwanted reflections from re-entering the laser cavity; **all-reflective beam expanders** for broadband applications where refractive designs are not practical; and **motorized beam expanders** for dynamic control of the laser-beam size in flying optic systems.

Our eV Products division is engaged in the development and uses of compound semiconductor materials for ionizing radiation detection applications, which include industrial gauging, security, medical imaging, and research and development.

Contact: II-VI Incorporated, 375 Saxonburg Blvd., Saxonburg, PA 16056; Tel. (412) 352-1504; FAX (412) 352-4980.

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NESLAB Instruments is a global supplier of recirculating chillers for use in the laser and optical equipment industries. These closed-loop chillers improve equipment performance by replacing unclean or unpredictable tap or building water with a coolant that is clean and free of minerals, organic matter, rust, or any number of pollutants. This allows for greater control of temperature, flow, and pressure of the coolant. Recirculating chillers offer trouble-free steady cooling with heat-load removal up to 75 kW, spanning temperatures of -5 °C to +35 °C. NESLAB offers 16 different chiller models as well as four water-to-water heat exchangers.

NESLAB's recirculating chillers feature 24-hour operation, LED display, operating status gauges, and easy access to internal components. Each cooling system can be ordered with temperature-control options, pump options, and an extensive list of customizing options. NESLAB's staff of design engineers and applications engineers can work closely with customers to design and manufacture equipment that will suit their needs exactly.

NESLAB offers world-class OEM product programs, and can offer special pricing, delivery, and custom engineering assistance to meet specific requirements. Years of successful relationships with major OEM customers have made NESLAB a first choice among manufacturers using temperature control in conjunction with their processes.

In addition to its USA locations, NESLAB has direct sales and service facilities throughout Europe and Asia. NESLAB is an ISO-9001 registered company, and all NESLAB products are backed by over 30 years' experience.

Contact: Terri Pruett, Marketing Coordinator, NESLAB Instruments, Inc., PO Box 1178, Portsmouth, NH 03802-1178; Tel. (603) 436-9444; FAX (603) 436-8411.

For More Information Write In No. 473

NEW LITERATURE

Infrared Materials

An eight-page full-color brochure from II-VI, Saxonburg, PA, describes the range of zinc selenide (ZnSe), regular-grade zinc sulfide (ZnS), and multispectral-grade zinc sulfide available from the company. The booklet lists physical, mechanical, and thermal properties as well as optical wavelength, refractive index, and thermo-optic coefficient. It also sets out standard tolerance specifications and surface finishes for its line of circular, rectangular, and square blanks and blanks with generated curved surfaces.

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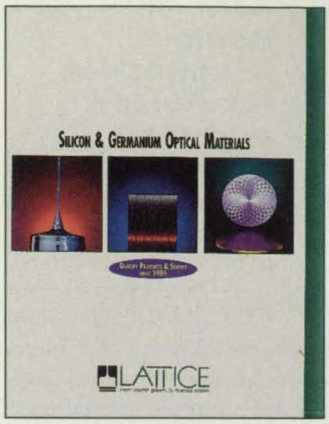

Silicon and Germanium Optical Materials

An eight-page full-color brochure from Lattice Materials Corp., Bozeman, MT, contains descriptions of the company's capabilities in crystal growth, testing, shaping and slicing, curve generation, polishing, and final inspection. Material specifications of silicon and germanium are also detailed, as well as fabrication and surface finish capabilities.

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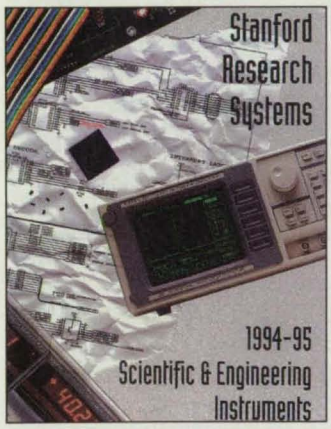

Signal Generation and Analysis Equipment

The "Scientific and Engineering Instruments" catalog from Stanford Research Systems, Sunnyvale, CA, has 176 pages of product and technical information, including more than 40 pages devoted to five instrumentation application notes. Features and specifications are detailed for a range of equipment including spectrum analyzers, function and digital delay generators, lock-in amplifiers, gated integrators and boxcar averagers, photon counters, and more.

For More Information Write In No. 808

Handheld CRT Tristimulus Colorimeter

Graseby Optronics, Orlando, FL, offers a four-page brochure describing its SLS 9400 handheld battery-operated CRT colorimeter. Ergonomically designed to rest comfortably in one hand, it operates from simple menu-driven commands. The brochure sets out specifications of accuracy and repeatability, as well as graphed spectral response curves compared with CIE response.

For More Information Write In No. 811

Fiber Access to Unusual Spectral Regions

Galileo Electro-Optics, Sturbridge, MA, offers a technical data sheet on its Fluorolase™ rare-earth-doped fluorozirconate (ZBLAN) fibers for use as fiber amplifiers, fiber laser sources, and sensors. Dopants of the four standard models include praseodymium, thulium, holmium, and erbium, allowing upconversion output regions of red, blue, and green, as well as IR. The fibers are manufactured by Galileo using proprietary technology licensed from British Telecom.

For More Information Write In No. 809

Precision Motion Control

The new edition of the positioning systems and components catalog from the MicroSlides division of Anorad Corp., Hauppauge, NY, contains 17 pages outlining components, slide assemblies, stages, and integrated systems. Included are crossed roller bearings and ways, linear and rotary positioning systems, and positioning controllers. Warranty policy is also spelled out.

For More Information Write In No. 812

NEW PRODUCTS

Beam Diagnostics for Pulsed and CW Sources

The LaserGauge™ from Coherent, Auburn, CA, offers compact size, speed, and ease of use in CCD-based beam diagnostics, the company says. It is compatible with all Coherent beam diagnostics cameras, including the new LaserCam. Any NTSC-compatible video monitor can be used with the LaserGauge. Features include full automatic triggering, background zero, and gain adjust. It also has an RS-232 serial port for remote data storage.

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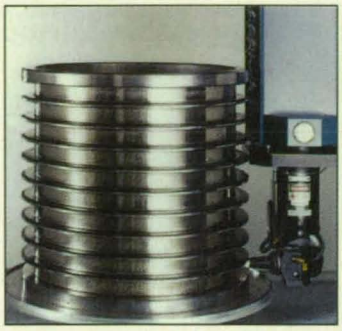

Programmable Gas Assist for Process Control

Lumonics, Eden Prairie, MN, announces that its full line of Laserdyne™ Multi-axis laser systems equipped with the System 94 Laser Process Control will have a new programmable gas-assist option. Called PresSure™, the feature provides control of assist-gas pressure from within the part program, eliminating the need to make pressure changes manually. Thus pressure can be precisely controlled from 0-200 psi. Pressure can also be quickly changed between optimums for a given area of a part.

For More Information Write In No. 804

Video Time Exposures with Peak Store

Colorado Video, Boulder, CO, announces the Model 443 video peak store, with a video memory capable of superimposing two or more images onto a single frame. Thus it provides the equivalent of a photographic time exposure. A standalone self-powered instrument, the 443 can be used with either a conventional TV camera or videotape. The company says it is ideal for capture of random transient events or for tracking moving objects.

For More Information Write In No. 802

Diode Laser Driver with Interface

The 06 DLD 203 diode laser driver, a microprocessor-driven low-noise current source and temperature controller from Melles Griot, Irvine, CA, comes with an IEEE-488.2 interface as a standard feature. The unit offers current- and power-stabilized modes of operation, modulation capability up to 1 MHz, and the ability to preset all diode laser and temperature values before laser turnon.

For More Information Write In No. 805

Carbon Dioxide TEA Laser

Laser Science Inc., Newton, MA, is offering its μ-TEA carbon dioxide laser with a sealed replaceable plasma cartridge. Emitting up to 10 mJ of multimode pulse energy at 10.6 micrometers, it operates at a repetition rate of up to 20 Hz. Its 200-ns pulse can deliver as much as 50 kW peak power for applications in mass spectrometry, laser-induced plasma spectroscopy, and detection calibration.

For More Information Write In No. 803

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The new INDEX-888 model that Lumonics, Kanata, Ontario, Canada, has added to its INDEX®-800 series of industrial excimer lasers can deliver stabilized energies of 600 mJ/pulse on KrF and 400 mJ/pulse on XeCl, both at repetition rates of up to 100 Hz. Designed for high-precision materials processing, Lumonics' workstations incorporating the INDEX 888s use a centralized laser and motion-control system with a Windows-based operating environment.

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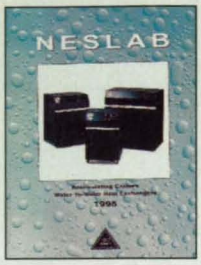

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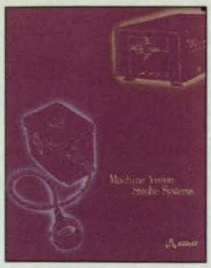

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EG&G Electro-Optics is known in the industry for producing high-quality strobe systems and for its ability to customize those systems for specific applications. This brochure contains individual data sheets which describe and specify the broad line of MVS systems and accessories used to provide uniform direct lighting, fiber optic lighting, or collimated lighting. EG&G Electro Optics, 25 Congress St., Salem, MA 01970; Tel: 508-745-3200; Fax: 508-745-0894.

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Stanford Research Systems

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Libbey-Owens-Ford Co.

For More Information Write In No. 374

NEW INFRARED OPTICS CATALOG FOR RESEARCHERS, MANUFACTURERS, AND OPTICAL ENGINEERS

II-VI Incorporated, Saxonburg, PA, a worldwide leader in IR laser optics, is now offering a 48 page, full color optics catalog. This catalog is designed to assist researchers, manufacturers and users with the proper selection and specification of optics. It features detailed information on all significant aspects of infrared optics, including IR Materials.

II-VI Incorporated

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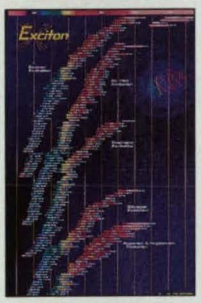

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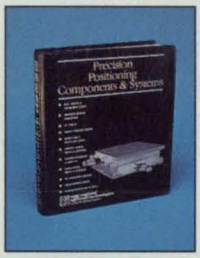

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Rofin Sinar, Inc.

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For More Information Write In No. 452

Probes Measure Slots

Marshall Space Flight Center, Alabama

Contact probes have been devised for measuring the depths and widths of slots. The slot-width-measuring probes can be configured in conical or wedge shapes, depending on the specific applications. The conical or wedge surface of a probe centers the probe in a slot, while two thin probe rods are made to protrude from the cone or wedge until their tips simultaneously make contact with the outer surface and the bottom of the slot. Data on depths are obtained by digitizing the voltage outputs of linear potentiometers connected to the two rods, then processing the digitized outputs in a computer. The data can be stored and/or used to generate displays for purposes of quality control.

This work was done by John E. Maslakowski and Jeffrey L. Gilbert of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 87*** *on the TSP Request Card. MFS-30052.*

Composite Cocured Modular Eggcrate-Core Sandwich Structure

Advantages include easier fabrication and better mechanical properties.

Langley Research Center, Hampton, Virginia

Lightweight composite-material (e.g., graphite fiber/epoxy matrix) cocured sandwich panels with eggcratelike cores are being developed for use as principal components of optical benches and other structures that support precise optical instruments. In comparison with structures (including composite structures) developed previously for this purpose, these structures offer greater thermal and mechanical stability. Unlike some of the previously developed structures, these structures can be fabricated without precise machining and precise alignment steps, and the remaining steps needed to fabricate these panels are fewer and simpler. Also, the core is fabricated without the use of adhesives, which reduces overall outgassing potential and weight contributions. Consequently, the fabrication times and costs are reduced.

The developmental panel structures can be made in many variations of the basic eggcrate core/sandwich design. As shown in Figure 1, the basic design calls for an aggregate of square modular composite-material core units bonded to each other on their mating sides, with face sheets bonded to the core. Four bonded core units intersect at each interior junction, providing a continuation of the properties of the composite material through the junction. The core units and face sheets can be made of a variety of matrix and fiber materials, laminated in a variety of layups and thicknesses, and assembled in a variety of geometries to impart the desired mechanical, thermal, and other properties to the finished structure.

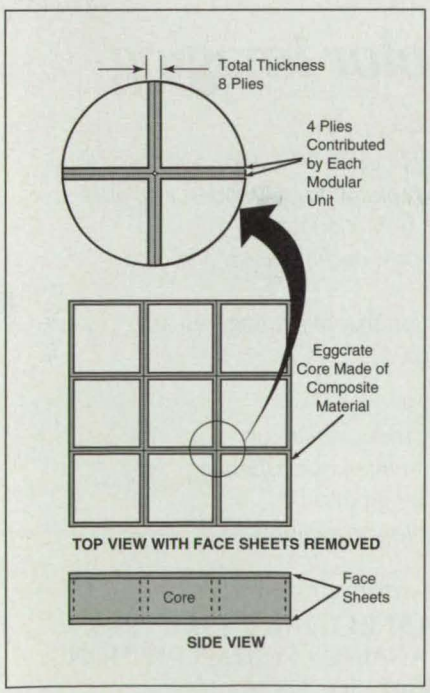

Figure 1. This **Structure Is Representative** of the eggcrate core/sandwich panel structures described in the text. A typical practical structure could be more complex: it could contain more cells and/or reinforcing and bonding tabs, or the cells could have different (e.g., hexagonal) shapes.

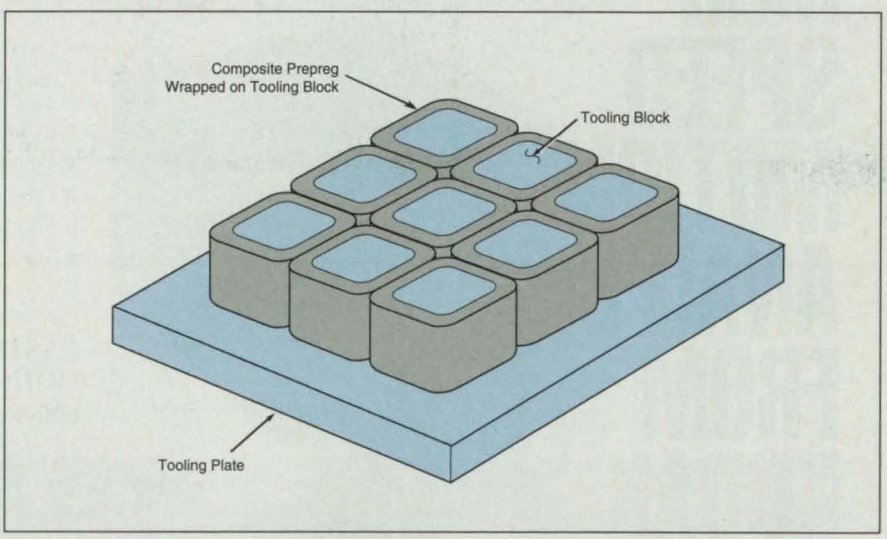

Figure 2. **Tooling Blocks Wrapped With Prepreg Strips** are assembled in preparation for curing the strips to form the eggcrate core.

Many variations in fabrication are also possible. A typical process for making a structure like that of Figure 1 begins with the preparation of strips of composite prepreg material, which is typically a laminate of four plies of graphite fibers (oriented at 0°, 45°, 90°, and –45°) with a partially cured epoxy matrix. These strips are cut to fit tooling blocks that serve as mandrels for the eggcrate core units. The prepreg strips are wrapped around the blocks, then the wrapped blocks are placed on a tooling plate and pushed together (see Figure 2), thus pressing the wrapped prepreg strips into a unitary core structure with adjacent units joined together in symmetric eight-ply (0°, 45°, 90°, –45°, –45°, 90°, 45°, 0°) walls. By use of a standard autoclave technique, the units are kept pressed together and heated to cure the epoxy, thus bonding the units together to form a rigid eggcrate core.

After the cure, the tooling blocks are removed from the core. Face sheets made of the same or a different composite material are then bonded secondarily to the core to complete the sandwich structure. Alternatively, one prepreg face sheet can be included in the tooling-plate/tooling-block/core-unit assembly and autoclave-cured along with the core units to obtain a unitary single-face-sheet/eggcrate-core structure; then the tooling blocks can be removed, and the other face sheet bonded secondarily to complete the sandwich structure. In yet another of many alternatives, both face sheets are included in the tooling-plate/tooling-block/core-unit assembly and autoclave-cured along with the core units to form a complete unitary sandwich structure. In this case, the tooling blocks must be made of a lightweight foam material that can be allowed to remain in the core, or else they could be made of a material that can be dissolved or melted, to remove them from the core after curing.

This work was done by Charles J. Magurany of Lockheed Engineering and Sciences Co. for **Langley Research Center.** *For further information,* ***write in 75*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center; (804) 864-9260. Refer to LAR-14898.

Cutting Tool for Shaving Weld Beads

Marshall Space Flight Center, Alabama

A cutting tool has been proposed for use in shaving weld beads flush with the adjacent surfaces of the weldments. The tool would be a modified version of a commercial pneumatically driven rotary cutting tool, the cutting wheel of which turns at speeds sufficient for machining nickel alloys, titanium, and stainless steels. The depth of the cutting wheel is adjustable in increments of 0.001 in. (0.025 mm). The tool could be equipped with a forward-mounted handle and a rear-mounted skid plate to maximize control and reduce dependence on the skill of the technician.

This work was done by David S. Hoffman of **Marshall Space Flight Center,** *and David C. McFerrin, Ronald L. Daniel, Jr., John B. Coby, Jr., and Sidney G. Dawson of Rockwell International Corp. For further information,* ***write in 88*** *on the TSP Request Card. MFS-30056.*

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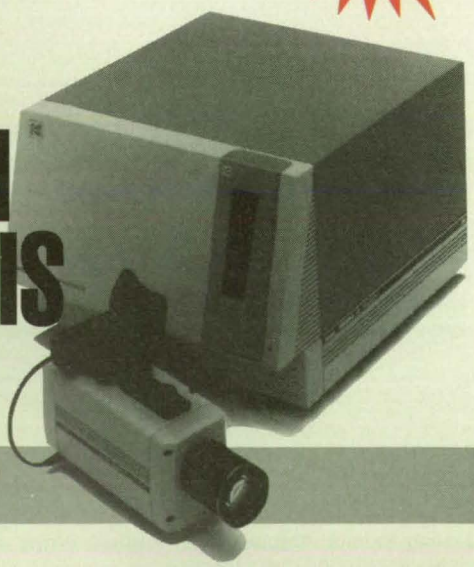

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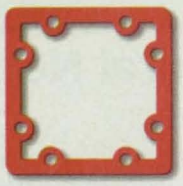
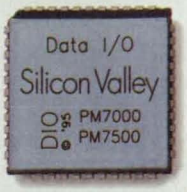


Gasket Manufacturing

Color Marking on Anodized Aluminum

Engraving Wood



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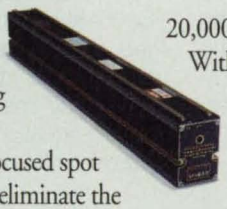

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For More Information Write In No. 538

Improved Adjoint-Operator Learning for a Neural Network

Temporally varying patterns could be learned in real time, with less computation.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved method of adjoint-operator learning reduces the amount of computation and the associated computational memory needed to make an electronic neural network learn a temporally varying pattern (e.g., to recognize a moving object in an image) in real time. This method is an extension of the method described in "Adjoint-Operator Learning for a Neural Network" (NPO-18352), *NASA Tech Briefs*, Vol. 17, No. 10 (October, 1993), page 55.

A lengthy description of the theoretical foundation of the method is prerequisite to give meaning to even a brief summary of the method. [A similar (but not identical) theoretical foundation was described in the noted prior article.] The evolution of a neural network is considered to be governed by the following set of coupled nonlinear differential equations:

$$\dot{u}_n + \kappa_n u_n = g_n\left[\gamma_n\left(\sum_m T_{nm} u_m + I_n\right)\right], t > 0$$

where u_n represents the output of the nth neuron and T_{nm} denotes the strength or weight of the synaptic coupling from the mth to the nth neuron. The constant κ_n characterizes the decay of neuron activity. The response of a neuron is governed by a sigmoidal function, g, and its gain, γ, typically, $g(\gamma x) = \tanh(gx)$. The time-dependent term $I_n(t)$, called the "source" term, encodes contribution of the nth component of the temporal pattern $\alpha(t)$ via the expression

$$I_n(t) = \begin{cases} \alpha_n(t) & \text{if } n \text{ denotes an input neuron} \\ 0 & \text{if } n \text{ denotes a hidden or output neuron} \end{cases}$$

The problem in learning is to adjust the synaptic-coupling strengths T_{nm} to minimize a quantity called the "neuromorphic energy functional," E, given by

$$E(\bar{u},\bar{p}) = \int_t \frac{1}{2}\sum_n \Gamma_n^2\, dt = \int_t F dt$$

where t = time, the integral is taken over some finite interval, and

$$\Gamma_n(t) = \begin{cases} \alpha_n(t) - u_n & \text{if } n \text{ denotes an output neuron} \\ 0 & \text{if } n \text{ denotes an input or hidden neuron} \end{cases}$$

The vector $\bar{p}$ denotes the system of N^2 (where N is the number of neurons) synaptic-coupling strengths:

$$\bar{p} = \{T_{11}, \ldots, T_{NN}\}$$

The solution of the learning problem begins with the formulation of the updating of the parameter vector $\bar{p}$ as a descent along the gradient of E in $\bar{p}$ space, starting from a guessed initial parameter vector. The dynamics of the neural network (as defined by the first equation presented above) are incorporated into the gradient descent by use of the adjoint operators. One begins with a set of equations called the "forward sensitivity equations":

$$\begin{cases} \dot{u}_{n,\mu} + \sum_m A_{nm} u_{m,\mu} = S_{n,\mu} & t > 0 \\ u_{n,\mu} = 0 & t = 0 \end{cases}$$

in which

$$A_{nm} = \kappa_n \delta_{nm} - \gamma_n \hat{g}_n T_{nm},$$

$$S_{n,\mu} = \gamma_n \hat{g}_n \sum_m T_{nm} u_m \delta_{p_\mu, T_{nm}},$$

$\hat{g}_n$ represents the derivative of g_n with respect to u_n, the subscript "$,\mu$" denotes partial differentiation with respect to the μth component of $\bar{p}$, and δ is the Kronecker delta for the identity tensor. It can be shown that the computational cost is reduced by the use of the adjoint functions, $\bar{v}$, the nth component of which is defined by one of the equations in a system of equations called "adjoint system of equations," namely,

$$-\dot{v}_n + \sum_m A^T_{nm} v_m = S^*_n$$

To put this equation in closed form, one must define the source term S^*_n and temporal boundary conditions. Both should be independent of p_μ and its derivatives.

To begin the derivation of the improved method, one multiplies the forward sensitivity equations by $\bar{v}$, and the adjoint system of equations by $\bar{u}_\mu$, subtracts the two resulting equations, integrates over the time interval (t_o, t_f), and selects the following new source terms and boundary conditions:

$$\begin{cases} \bar{S}^* = \frac{\partial F}{\partial \bar{u}} \\ \bar{v}(t = 0) = 0 \end{cases}$$

The resulting equation is

$$\int_t \frac{\partial F}{\partial \bar{u}} \bar{u}_{,\mu}\, dt \equiv \int_t \bar{S}^* \bar{u}_{,\mu}\, dt = \int_t \bar{v}\, \bar{S}_{,\mu}\, dt - \left[\bar{v}\, \bar{u}_{,\mu}\right]_{t_f}$$

The computations of the gradient descent then involve two stages, which correspond to the two terms on the right side of this equation. The first term is computed by use of the adjoint functions; the number of arithmetic operations in this computation is proportional to N^2L, where L is the number of time steps used in numerical integration.

The main difficulty resides with the evaluation of the second term. To compute it, the authors introduce an auxiliary adjoint system of equations:

$$-\dot{z}_n + \sum_m A^T_{nm} z_m = \hat{S}_n, \; t > 0$$

By choosing

$$\hat{\bar{S}} = \bar{v}(t)\delta(t - t_f)$$

$$\bar{z}(t_f) = 0$$

the authors can show

$$\left[\bar{v}\, \bar{u}_{,\mu}\right]_{t_f} = \int_{t_o}^{t_f} (\bar{z}\, \bar{S}_{,\mu}) dt$$

Note that, even though the authors selected $\bar{z}(t_f) = 0$, they are still interested in solving the auxiliary adjoint system, forward in time. Thus, the critical issue is how to select initial condition [i.e., $\bar{z}(t_o)$], that would result in $\bar{z}(t_f) = 0$. It has been demonstrated that these initial and final conditions are related via a propagation kernel. Hence, computation of $\left[\bar{v}\, \bar{u}_{,\mu}\right]_{t_f}$ involves two substages: a kernel propagation that entails a number of arithmetic operations proportional to N^3L, and a numerical integration that requires a matrix•vector multiplication at each time step and entails a number of arithmetic operations proportional to N^2L. Thus, the overall number of arithmetic operations is approximately proportional to N^3L. However, the amount of computer memory required is minimal, being proportional to only N^2.

This work was done by Nikzad Toomarian and Jacob Barhen of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 132*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries

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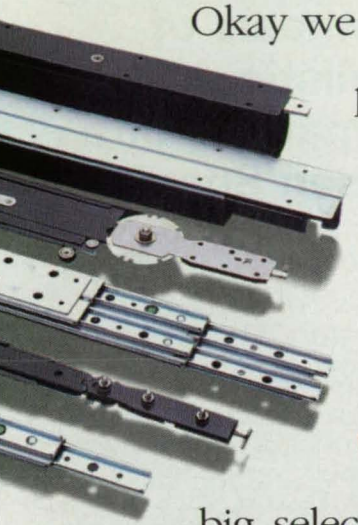

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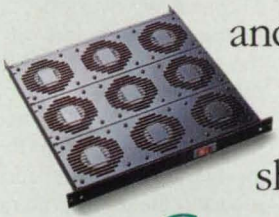

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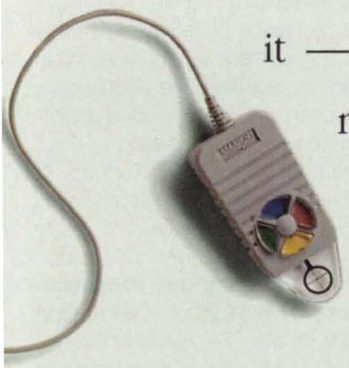

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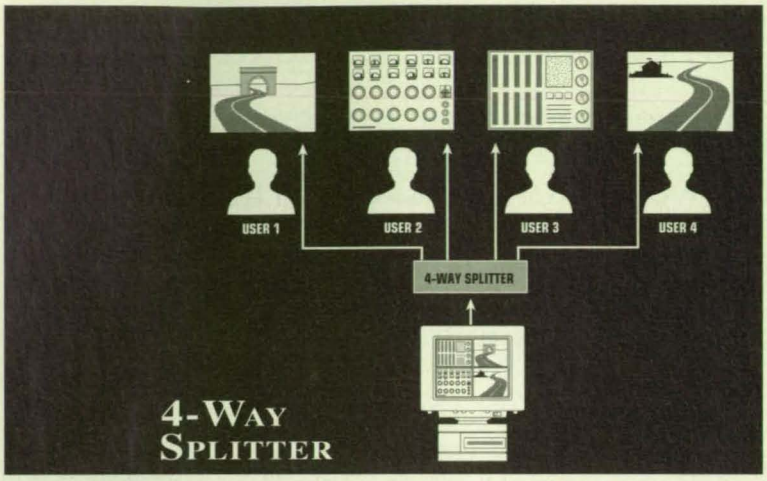

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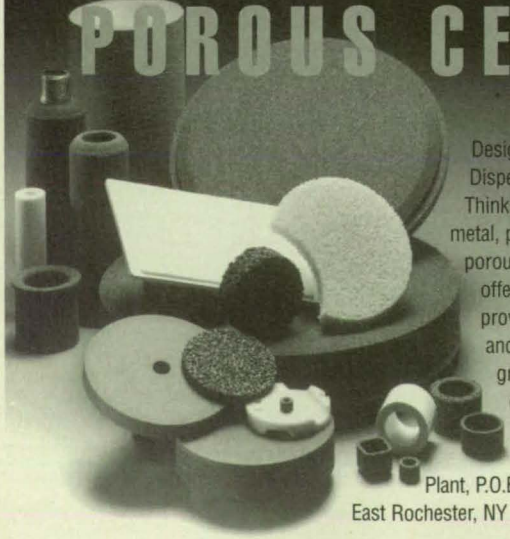

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Synthesis of Realistic Animations of a Person Speaking

Sequences of video images are produced automatically.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Actors computer program implements an automated process that synthesizes realistic animations of a person speaking. Previously, artists made such animations through a tedious, labor-intensive process usually for cartoons and cartoonlike productions. The present application of the automated process produces "newscaster" type video sequences. The process uses images of a person and, therefore, is not limited to cartoons and cartoonlike movies. Potential applications also include use of the process for automatically producing on-the-fly animations for human/computer interfaces and for reducing the bandwidth needed to transmit video telephone signals. In preparation for the automated process, one assembles a database of video images representing the subject's face uttering individual phonemes. From the database, Actors synthesizes a sequence of images that correspond to a given spoken phrase. When played back in real-time, the sequence of images appears as a movie of a realistic human figure speaking naturally.

This work was done by Kenneth C. Scott, David S. Kagels, Stephen H. Watson, Hillel S. Rom, Jean J. Lorre, John R. Wright, and Elizabeth D. Duxbury of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 29*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-19494, volume and number of this NASA Tech Briefs *issue, and the page number.*

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Compact, Automated, Frequency-Agile Microspectrofluorimeter

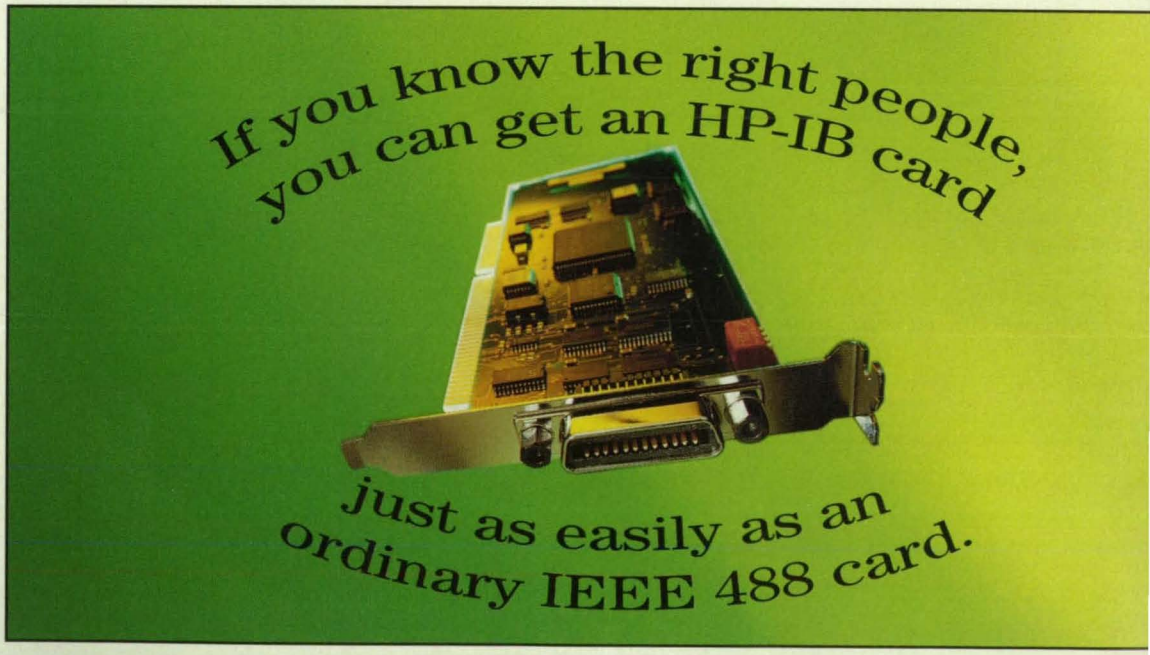
Advanced features would be combined to obtain a highly useful apparatus.

John F. Kennedy Space Center, Florida

A compact, reliable, rugged, automated cell-culture and frequency-agile microspectrofluorimetric apparatus is being developed to perform experiments that would involve photometric imaging observations of single live cells. In the original application for which it was conceived, the apparatus would operate mostly unattended aboard a spacecraft; potential terrestrial applications include automated or semiautomated diagnosis of pathological tissues in clinical laboratories, biomedical instrumentation, monitoring of biological process streams, and portable instrumentation for testing biological conditions in various environments. The apparatus would offer obvious advantages over present laboratory instrumentation that is large and delicate, must be operated manually and attended frequently, and has limited capability for spectral measurement and/or imaging at only a few wavelengths.

The apparatus (see Figure 1) would contain modules that would accommodate multiple samples of live animal and plant cells, provide for automatic addition of various substances to stimulate the cells, bring cell cultures to a microscope stage for spectrally resolved illumination and spectrally resolved imaging, and translate the stage to scan for cells of interest. The specimen culture on the stage would be illuminated by light at a chosen wavelength or combination of wavelengths, and would be imaged in the microscope at another wavelength or wavelengths — for example, the wavelength(s) of fluorescence excited in a particular substance of interest that binds to specific cell components and is thus indicative of cell structure. A charge-coupled-device video camera attached to the microscope would acquire the image. A computer in the apparatus would process and store the spectrally resolved image data acquired by the camera.

Of the many advanced features of this apparatus, one would contribute the



most to its miniaturization, frequency agility, and ruggedness, and to its relative simplicity in comparison with other apparatuses in which various illumination and observation spectra are obtained by mechanical switching of fixed-wavelength, band-pass filters and dichroic mirrors. That feature is the use of one or two acousto-optical tunable filters (AOTF's): optionally, one to obtain the illumination spectrum by filtering light from a xenon arc lamp, and the other to select the wavelength(s) of light from the specimen to be imaged in the camera (see Figure 2). AOTF's are solid-state electronically tunable devices that have no moving parts, are small, and can be switched rapidly from one wavelength to another. A conventional mechanically switched monochromator of high wavelength resolution (0.5 nm resolution in the wavelength range of 400 to 520 nm) occupies a volume of about 2,250 in.^{3} (about 3.7 × 10^4 cm^3) and can switch among a few wavelengths no more frequently than a few times per second. An AOTF designed to operate in the same spectral region would occupy a volume of only about 1 in.^{3} (about 16 cm^3) and could be tuned continuously in wavelength and/or switched among an unlimited number

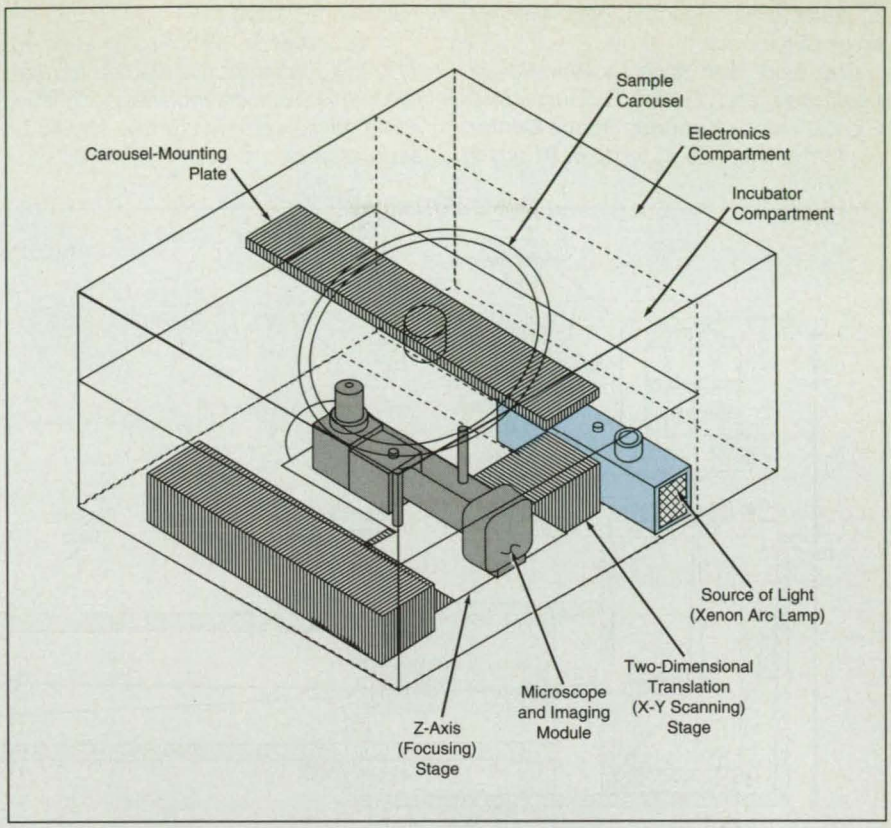


Figure 1. The **Compact, Automated, Frequency-Agile Microspectrofluorimeter** would be a versatile, portable apparatus that would be useful in microbiological, medical diagnostic, process-monitoring, and environment-monitoring applications.

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of discrete wavelengths, with switching times of the order of 10 μs.

This work was done by Salvador M. Fernandez and Ernest F. Guignon of Ciencia, Inc. for **Kennedy Space Center.** *For further information,* ***write in 91*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to KSC-11611, volume and number of this NASA Tech Briefs *issue, and the page number.*

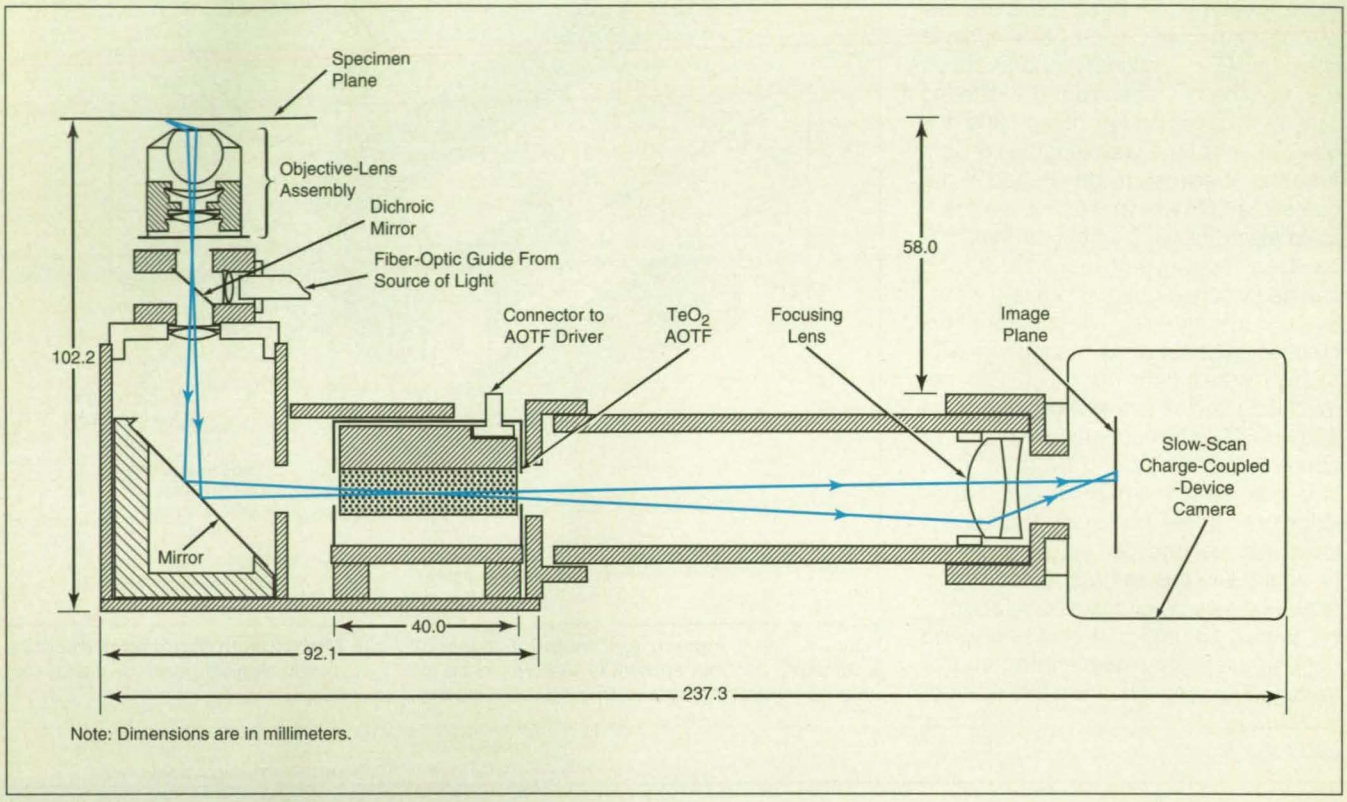


Figure 2. The **Microscope Optics** in the microspectrofluorimeter would include an acousto-optical tunable filter, which would provide control of the image spectrum, with rapid switching or scanning of the wavelength passband(s).

Modified, Packaged Tortillas Have Long Shelf Life

Part of the water in the recipe is replaced with glycerin.

Lyndon B. Johnson Space Center, Houston, Texas

Tortillas have been made from a modified recipe and sealed in low-pressure nitrogen in foil pouches in an effort to increase their shelf life at room temperature. Preliminary tests show that the shelf life of these tortillas is at least five months; in contrast, commercial tortillas last only a few days.

The ingredients in the modified recipe are similar to those of the basic tortilla recipe except that some of the water is replaced by glycerin to inhibit the growth of microorganisms. It is particularly necessary to avoid *Clostridium botulinum*, which can grow in anaerobic environments and produce the deadly toxin that causes botulism. The minimum water activity (the ratio between the partial pressure of water in the tortilla and the partial pressure of pure water) below which *Clostridium botulinum* cannot grow is about 0.90.

Accordingly, the proportions of water and glycerin in the modified recipe (see table) were chosen by experimentation to achieve a sufficiently low water activity (about 0.88) to prevent the growth of *Clostridium botulinum* while maintaining acceptable taste. A preference test showed that there is no significant difference between the taste of the long-shelf-life tortillas and commercial tortillas.

Ferrous salts are added to each foil package to remove any oxygen that remains inside after sealing in the tortillas with nitrogen. These measures prevent mold and yeast from growing on the tortillas after packaging. The factor that limits shelf life is now the retrogradation of the starch fraction of the tortillas; that is, the tortillas grow stale.

This work was done by Charles Bourland of **Johnson Space Center** *and Kimberly Glaus-Late of Lockheed Engineering and Sciences Co. For further information,* ***write in 23*** *on the TSP Request Card. MSC-22406*

Ingredient	Percent by Weight
Wheat Flour	61.79
Water	26.58
Glycerin	4.02
Shortening	3.71
Mono/diglycerides	1.24
Salt	0.99
Baking Powder	0.87
Dough Conditioner	0.31
Fumaric Acid	0.19
Potassium Sorbate	0.15
Carboxymethyl Cellulose	0.12
Calcium Propionate	0.03

The **Ingredients of Long-Shelf-Life Tortillas** are similar to those of ordinary tortillas, except that some of the water is replaced with glycerin to inhibit the growth of deadly Clostridium botulinum.

Books & Reports

These reports, studies, and handbooks are available from NASA as Technical Support Packages (TSPs) when a Request Card number is cited; otherwise they are available from the NASA Center for Aerospace Information.

Machinery

Experiment To Test Raster Scanning With RUM Actuator

A report describes a proposed experiment to demonstrate the feasibility of using a rotating-unbalanced-mass (RUM) actuator to effect raster scanning of an instrument mounted in a two-axis gimbal. [A conceptual RUM and an auxiliary RUM control mechanism are described in "Auxiliary Mechanisms for Rotating-Unbalanced-Mass Actuators" (MFS-28817), which appears elsewhere in this issue of *NASA Tech Briefs*.] The report discusses the design of the experimental apparatus, which would include a gimbal-mounted I-beam (to represent the scanning instrument), two RUM actuators on the beam to effect the rapid component of the raster motion, stepping motors at the gimbals to establish commanded center-of-scan angles and to effect the slow component of raster motion, and electronic control circuitry. The report presents the results of a computer simulation of the experiment, concluding that the apparatus should perform well in both line and raster scans and in both zero and normal Earth gravitation.

This work was done by W. D. Lightsey, D. C. Alhorn, and M. E. Polites of **Marshall Space Flight** *Center. Further information may be found in NASA TP-3249 [N92-29677/TB], "Definition and Design of an Experiment To Test Raster Scanning With Rotating Unbalanced-Mass Devices on Gimbaled Payloads."*

Copies may be purchased [prepayment required] from the NASA Center for AeroSpace Information, Linthicum Heights, Maryland, Telephone No. (301) 621-0394. Rush orders may be placed for an extra fee by calling the same number. MFS-28771

Shape-Memory-Alloy Actuator for Flight Controls

A report proposes the use of shape-memory-alloy actuators, instead of hydraulic actuators, for aerodynamic flight-control surfaces. An actuator made of a shape-memory alloy could convert thermal energy into mechanical work by changing shape as it makes the transitions between the martensitic and austenitic crystalline phase states of the alloy. Changes in shape can be tailored since the transformation temperatures can be selectively tuned over a broad range. The response times of a shape-memory-alloy actuator are directly controlled via the rates of heating and cooling. Because both hot exhaust gases and cryogenic propellant liquids are available aboard launch rockets, shape-memory-alloy actuators should be exceptionally suited for use aboard such rockets.

This work was done by Chris Barret of **Marshall Space Flight Center**. *To obtain a copy of the report, "Launch Vehicle Shape Memory Alloy Actuation for Flight Control Augmentation Devices,"* ***write in 73*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-31033.

Electronic Components and Circuits

Back-to-Back Barrier Varactor Frequency Multipliers

Two reports present further detailed information about the odd-harmonic frequency-multiplier devices described in "Barrier/n/n^+ Varactor Frequency Multipliers" (NPO-18428), *NASA Tech Briefs*, Vol. 16, No. 8 (August, 1992), page 28. These devices comprise Schottky-barrier/n/n^+ diodes in a planar back-to-back configuration. The symmetry of the configuration gives rise to symmetry of nonlinear voltage-vs.-current characteristics, with resultant suppression of even harmonics and elimination of the need for dc bias.

This work was done by Debabani Choudhury, R. Peter Smith, Suzanne C. Martin, Antti Räisänen, and Margaret A. Frerking of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain copies of the reports, "Characterization and Analysis of Back-to-Back Barrier-N-N^+ (bbNN) Varactor Devices for Millimeter and Submillimeter Wave Frequency Multipliers," and "Experimental Evaluation and Theoretical Analysis of Back-to-Back Barrier-N-N^+ (bbNN) Varactor Frequency Multipliers for Millimeter and Submillimeter Wave Applications,"* ***write in 62*** *on the TSP Request Card. NPO-19232*

Mechanics

Uncertainty in Measuring Loads on Launch-Pad Supports

A report describes a study of uncertainty in measurements of loads in structural members of the launch pad of the space shuttle. The measurements were taken by strain gauges installed on the members. Calibration data for the study were obtained by removing each thus-instrumented member from the structure and measuring its individual response on a test stand.

This work was done by J. S. Townsend of **Marshall Space Flight Center** *and J. A. Richardson of the University of Alabama. To obtain a copy of the report, "Characterizing the Uncertainty in Holddown Post Load Measurements,"* ***write in 42*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28861.

Mass-Additive Vibration Testing of Constrained Structures

A report describes a study of the mass-additive method of modal survey testing of flexible structures that, in normal use, are constrained by other structures. In the mass-additive method, a structure that would normally be constrained by another structure is suspended freely and extra masses are attached to its boundary. The free-free vibrational mode shapes of the mass-loaded structure are measured and used to estimate the constrained-boundary modes of the structure in the absence of additional masses. Both the measured free-free vibrational modes and the esti-

mated constrained modes may be used to assess accuracy of a mathematical model and to update or refine the model.

This work was done by John R. Admire, Michael L. Tinker, and Edward W. Ivey of **Marshall Space Flight Center.** *To obtain a copy of the report "Mass-Additive Modal Test Method for Verification of Constrained Structural Models,"* ***write in 10*** *on the TSP Request Card. MFS-28998*

Studies of Residual Flexibility and Vibration Testing

A collection of reports presents theoretical and experimental studies in which the concept of residual flexibility is applied to modal vibration testing and verification of mathematical models of vibrations of a flexible structure constrained by another structure. "Residual flexibility" represents the effects of higher frequency structural modes not measured in the test. That is, it denotes that part of the interface flexibility due to mode shapes out of the frequency range of the test. These studies are directed, in particular, toward assessing the residual-flexibility approach as a substitute for fixed-base vibrational testing of payloads that are to be installed in spacecraft.

This work was done by John R. Admire, Michael L. Tinker, Paul S. Bookout, and Edward W. Ivey of **Marshall Space Flight Center**. *To obtain copies of the reports, "Residual Flexibility Test Method for Verification of Constrained Structural Models," "Shuttle Payload Modal Testing Techniques," "Analysis of Residual Flexibility Modal Test Data," "Statistically Generated Weighted Curve Fit of Residual Functions," "Measurement of Residual Flexibility for Substructures Having Prominent Flexible Interfaces," and "Cost-Effective Test Methods for Shuttle Payloads,"* ***write in 71*** *on the TSP Request Card. MFS-28999*

Materials

Depositing Adherent Ag Films on Ti Films on Alumina

A report discusses the cleaning of ceramic (principally, alumina) substrates in preparation for the sputter deposition of titanium intermediate films on the substrates followed by the sputter deposition of outer silver films. In the principal intended application, the substrates would be sliding parts in advanced high-temperature heat engines, and the outer silver films would serve as solid lubricants: the lubricating properties were described in "Solid Lubricant for Alumina" (LEW-15495), *NASA Tech Briefs*, Vol. 17, No. 12 (December, 1993), page 65.

This work was done by Frank S. Honecy of **Lewis Research Center.** *To obtain a copy of the report "Deposition of Adherent Ag-Ti Duplex Films on Ceramics in a Multiple-Cathode Sputter Deposition System,"* ***write in 67*** *on the TSP Request Card. LEW-15906*

Electrically Conductive White Thermal-Control Paint

A report describes the development of a white thermal-control paint intended for use on spacecraft. The paint was required to exhibit a combination of high emittance (≥0.90), low absorptance (≤0.20), and electrical conductivity sufficient to prevent charging with static electricity to potentials beyond the range of ±10 V. In tests, it exhibited an average measured emittance of 0.91 and an average measured absorptance of 0.20.

This work was done by Cheng-Hsien Hsieh, Gustaf A. Forsberg, and Timothy P. O'Donnell of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 65*** *on the TSP Request Card. NPO-19243*

Computer Programs

Technology of Controlled-Environment Agriculture

A report discusses controlled-environment agriculture (CEA) for commercial production of organisms, whether plants or animals. Using controlled ecological life-support systems, environments are manipulated to fulfill human requirements for food, oxygen, and water by regenerative processing of waste streams to supply plant inputs. CEA is already being practiced in greenhouses to produce food on nonarable lands. The report describes a conceptual regenerative system that incorporates biological, physical, and chemical processes to support humans in extraterrestrial environments. Green plants would utilize light energy to produce potable water, food, and oxygen while removing carbon dioxide, water, and inorganic elements from air and waste streams. Recycling of resources would involve the use of energy to control the fluxes of various materials in a biologically stable setting.

This work was done by David L. Bubenheim of **Ames Research Center** *and Maynard E. Bates of The Bionetics Corp. To obtain a copy of the report, "Applications of CELSS Technology to Controlled Environment Agriculture,"* ***write in 53*** *on the TSP Request Card. ARC-13219*

Manufacturing/ Fabrication

Apparatus for Making Glass Fibers Without the Aid of Gravity

A report describes an apparatus for making optical fibers in microgravity. The apparatus includes a sting that makes initial contact with softened glass to start drawing a fiber. The absence of gravity helps to suppress the nucleation of crystallites, which increase scattering of light and thus reduce the transmission of light along a fiber. To prevent abrasion of the surface of the fiber and absorption of water in the fiber, an ultraviolet-curable acrylic material can be automatically applied.

This work was done by Dennis Tucker of **Marshall Space Flight Center** *and Guy A. Smith and Gary Workman of the University of Alabama in Huntsville. To obtain a copy of the report, "A Glass Fiber Pulling Apparatus for Use in Low Earth Orbit,"* ***write in 89*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26339.

Welding Using Chilled-Inert-Gas Purging

A report describes a study of fusion welding using chilled inert gas. Marked improvement was shown in the welding of aluminum using chilled helium gas. Purging with inert gas during welding of a metal has produced improvements in the finished surfaces of weld roots, with formation of relatively smooth surfaces and suppression of formation of oxides.

continued on page 94

SPECIAL ADVERTISING SUPPLEMENT TO NASA TECH BRIEFS

TECHNOLOGY LEADERS

Profiles Of Pathsetting Companies Serving The Engineering Field

ADAPTIVE RESEARCH

Adaptive Research of Huntsville, Alabama, is a leading developer of Computational Fluid Dynamics (CFD) software for simulation of physical processes involving fluid flow and heat transfer. Adaptive was acquired last year by Pacific-Sierra Research Corp. of Santa Monica, enhancing the financial and technical resources of the experienced CFD research and development operation. Following 23 consecutive years of growth and nearly $30 million in revenues in 1993, the new acquisition reaffirms Pacific-Sierra's commitment to expand investment in advanced scientific software products. Pacific-Sierra is healthy, debt-free, and 100% employee owned.

Adaptive's CFD2000® software offers a fully integrated solution for modeling fluid flow, heat transfer, and other physical phenomena. From the intelligent window environment, the analyst can address all aspects of the simulation–including geometry and computational grid, fluid and material properties, initial and boundary conditions, solution monitoring and control, and even 3D field visualization and animation.

Adaptive Research is positioned on the leading edge of CFD technology with new methods utilizing unstructured grid generation and adaptive mesh refinement techniques. Linear tetrahedral elements and automatic remeshing allow for flow calculations over very complex surface shapes and can even compute the associated rigid-body motion dynamics.

In Santa Monica, Pacific-Sierra's Computer Products group is a leading authority on Fortran 90 compiler products, automatic parallelization software for high-speed systems, and superscalar Fortran and C optimization technology. The VAST® System is a suite of software tools that optimize and translate Fortran and C programs on today's superscalar workstations, parallel processors, and mainframe supercomputers.

For more information, contact Pacific: Computer Products Group, Pacific-Sierra Research Corp., 2901 28th St., Santa Monica, CA 90405; Tel: 310-314-2300; Fax: 310-314-2323; E-mail: info@psrv.com.

Adaptive Research Division, 4960 Corporation Drive, Suite 100A, Huntsville, AL 35805; Tel: 205-830-2620; Fax: 205-830-2628; E-mail: info@arc-cfd.com.

For More Information Write In No. 760

ALGOR, INC.

Algor Houdini: the Only Automatic CAD Solid Model to 8-Node "Brick" Finite Element Mesh Converter

Algor, Inc. is a leading maker of mechanical engineering analysis and design optimization software for UNIX, Windows NT, and Pentium processor-based workstations. More than 11,000 engineers in more than 60 countries use Algor software.

Algor's Houdini is the first software which takes CAD solid models from Pro/ENGINEER, EDS/Unigraphics, CATIA, Auto CAD, Cadkey, Intergraph, SDRC, and others and automatically creates 8-node "brick" finite element meshes for use in popular FEA programs, including Algor, Abaqus, Ansys, Cosmos, Nastran, NISA, Patran, Procast, and SDRC.

Houdini's Menupak user interface streamlines the mesh generation process and presents input and output file format choices on a single screen. Houdini's many advanced global mesh control options are specified from a point-and-click menu.

Houdini is featured in *The World of Houdini*, a new video training kit that demonstrates how to use Houdini in a variety of modeling scenarios. These include automatic 8-node "brick" finite element mesh generation, global mesh optimization controls, and advanced mesh manipulation capabilities which help engineers deal with complex finite element modeling and analysis challenges.

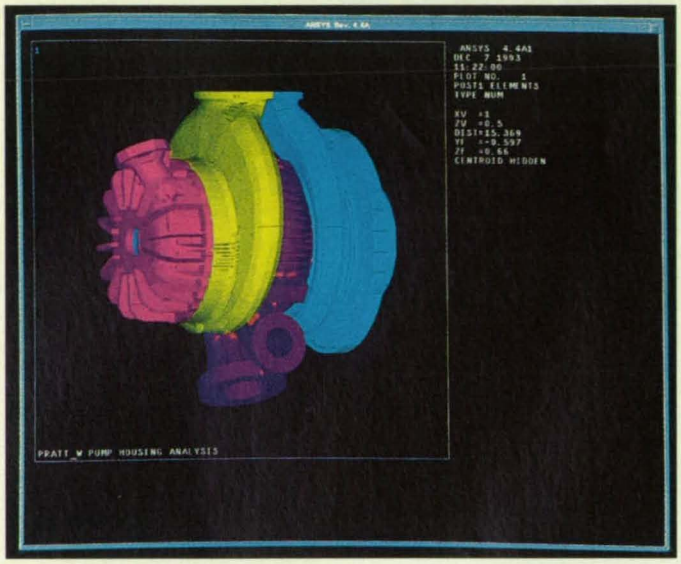
The video training kit includes a high-quality video, the complete training notes from Algor's two-day Houdini Education Seminar, a CD-ROM with the models used in the video, and Viewpak software for viewing the models on your computer.

Houdini enables engineers to have the level of control over the generated mesh desired for their analysis needs. *The World of Houdini* video training kit helps engineers develop the skills needed to use Houdini more effectively.

For More Information Write In No. 761

ANSYS, INC.

ANSYS, Inc., located in Houston, PA, has been a leader in design and analysis software for 25 years. John Swanson, the company founder and chief technologist, is internationally recognized as an innovator in computer software technology. TA Associates, a large investor in growth companies, recently acquired majority ownership in ANSYS. Peter Smith, a former top executive with Digital Equipment Corporation, has been named chief executive officer and will lead ANSYS into its next growth phase.



ANSYS is one of the most widely recognized large-scale programs for finite element analysis (FEA), allowing engineers to construct computer models, apply design criteria, and analyze responses. It is used in a variety of industry applications, including aerospace, government, defense, power machinery, biomechanics, and electronics.

ANSYS solves complex design problems because of its powerful capabilities, including preprocessing, postprocessing, and design optimization, along with structural, thermal, magnetic, fluid flow, coupled field, and nonlinear analyses. ANSYS Revision 5.1 features a completely redesigned graphical user interface (GUI) focusing on ease of use.

The illustration shows a 3D model of the HPOTP (High Pressure Oxidizer TurboPump), used on the space shuttle. Engineers at Sverdrup Technology, Marshall Space Flight Center, worked in conjunction with Pratt and Whitney to design an improved turbopump to replace one built in the 1970s. The different colors represent components or the element type numbering for the different regions of the housing.

Contact: ANSYS, Inc., 201 Johnson Road, Houston, PA 15342-1300; Tel: 412-746-3304; Fax: 412-746-9494.

For More Information Write In No. 762

ASTRO-MED, INC.

Astro-Med challenged the established beliefs of the recorder industry eight years ago when it introduced the first all-recorder chart recorders with "no moving parts," thus casting aside galvanometric technology that depends on a moving stylus to record data.

Since that time, Astro-Med has introduced four generations of its "New Technology" recording systems, each more powerful than its predecessor, and today Astro-Med believes that it is the industry leader. R&D is the key to Astro-Med's success. The company spends 7% of its revenue annually on new product development.

The MT95K2 is a typical example of Astro-Med's wave of revolutionary product development. Not only does it operate with "no moving parts" and record with laser printer resolution, but the recorder permits the user to see the data on a monitor as it is being recorded on chart paper. In addition, the user can program the recorder through a floppy disk as well as store the data internally for subsequent review. These are but a few of the advanced features that have put the K2 in a class by itself.

Recently the Dash IV and Dash 10 portable recorders joined the New Technology recorder family. Each offers unsurpassed capabilities combined with true portability provided by its internal battery, and both have big, bright, high-response monitors for viewing data and for easy chart setups.

Astro-Med has also extended its technology to other specialty printers. One specialty printer, the Tough Printer, is a ruggedized high-speed printer that supports multiple printer languages such as Postscript and PCL5. The Tough Writer is ideal for use on aircraft test flights, on ships, or in heavy industry.

With its R&D efforts continuing in high gear, Astro-Med has several exciting new graphic recorder products in various stages of development.

Contact: Astro-Med, Inc., Astro-Med Industrial Park, West Warwick, RI 02893; Tel: 800-394-3633; Fax: 401-822-2430.

For More Information Write In No. 763

DATA TRANSLATION

Data Translation's DT-Open Layers Software for Windows Makes Your Job Easier

Data Translation's® two premier applications under the DT-Open Layers® standard for Windows™ development offer you unparalleled ease-of-use and productivity gains without compromising power and functionality.

DT VEE™ for Windows is a comprehensive visual programming language that uses icons or objects, instead of text, to develop your data acquisition applications–fast.

Begin with DT VEE's high-level objects that acquire, process, display, and share data. Program intuitively by connecting these objects in a logical sequence. Then run. It's that easy.

DT VEE's graphical user interface creates the man-machine interaction you need, whether it is for detailed laboratory applications, production line controls or manufacturing test.

Programs can be changed dynamically–add, replace, or delete objects on-the-fly-for fast debug. Automatic wiring makes connections between objects foolproof–DT VEE won't let you create "bad" wires.

You can expand capabilities by creating user objects that combine DLLs, other DT VEE objects, or your own tried-and-true algorithms. You can create your own objects, too, and reuse your code from application to application.

DT VEE is fully compliant with the DT-Open Layers standard. Plus, DT VEE is based on HP VEE for Windows™, and is backed by the Hewlett-Packard and Data Translation commitment to quality.

GLOBAL LAB Image® marks a revolutionary advancement in PC-based scientific image analysis. An innovative architecture accommodates Add-In Modules that allow you to easily incorporate a variety of specialized functions into the already feature-rich GLOBAL LAB Image.

GLOBAL LAB Image puts an end to compromise. Modularity gives you the ability to add powerful, new capabilities to the easiest-to-use imaging package, while retaining its affordability. New modules are written as Windows DLLs, and their icons appear as tools in the GLOBAL LAB Image toolbox. In these ways, GLOBAL LAB Image continues to grow with your changing application needs.

Both DT VEE and GLOBAL LAB Image run on Data Translation's new data acquisition boards and frame grabbers for the PCI bus.

To test-drive DT VEE or GLOBAL LAB Image, call for a free evaluation at 800-525-8528.

For More Information Write In No. 764

DAVID SARNOFF RESEARCH CENTER

The David Sarnoff Research Center, a subsidiary of SRI International, conducts research in consumer electronics, solid-state physics, materials science, and communications.

Sarnoff is a client-supported facility with expertise in software and digital IC design, process and materials research, digital signal processing hardware and software, electromechanical devices, and displays. This expertise is applied to projects for both commercial and government customers.

Many of the major advances in electronics during the past 50 years have been pioneered at Sarnoff in West Windsor, NJ. Originally it was established as RCA Laboratories, but after RCA was sold to General Electric in 1986, the Sarnoff Center became part of SRI International, in Menlo Park, CA. Developments made at Sarnoff include color television, high-speed computer memories, injection lasers, liquid crystal technology, solid-state amplifiers for satellite communications, MOS transistors and logic arrays, and optical and capacitive video disc systems.

To be competitive in the Information Age, Sarnoff is finding new and different ways to "partner" with clients to leverage resources and maximize benefits. Rather than adhere to one narrowly defined business model, Sarnoff's approach is to be flexible and to add value to product development.

The David Sarnoff Research Center offers a full line of visible and infrared detectors and cameras, as well as III-V semiconductor components.

Examples of partnering efforts include continuing participation in the Grand Alliance, which is developing a system for HDTV; membership in the Phosphor Technology Center of Excellence, bringing together academia, government, and industry to develop advanced phosphor technology; and being a founding member of the Consortium for Educational Process and Technology to develop collaborative and long-distance learning techniques.

Sarnoff is also commercializing some of its own technologies through new spin-out companies. SENSAR, the first spin-out, was introduced in 1992 to commercialize computer vision hardware and software, and now has three products on the market. A second company will target the video server and video production markets.

Whether it be helping a client bring a product to market, forming alliances to advance R&D, or spinning out new companies that will attack electronic imaging problems, Sarnoff expects to play a significant role in the evaluation of digital imaging technologies.

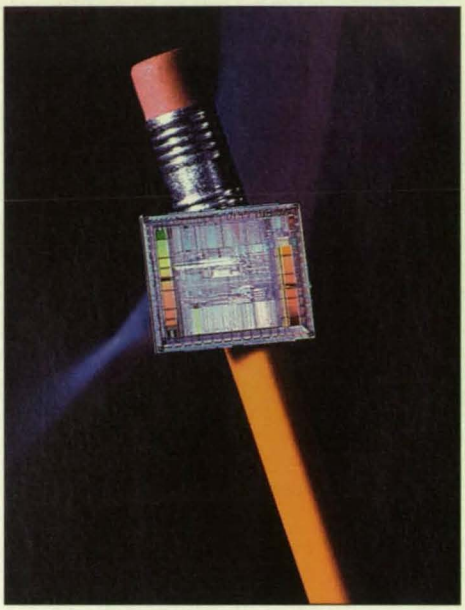
For more information, please contact Manager, Media Relations, David Sarnoff Research Center, CN 5300, Princeton, NJ 08543-5300; Tel: 609-734-3038; Fax: 609-734-2870.

For More Information Write In No. 765

DIGITAL EQUIPMENT CORPORATION

More than two years ago, Digital Equipment Corporation began charting a new course to reflect the rapidly changing dynamics of the marketplace and of customer needs and expectations. In many ways, Digital returned to its roots as an industry leader in networking and enterprise-wide computing. But to adapt to a new competitive environment, the company had to make some fundamental changes in the way it does business–from organization structure to its approach to the market.

Although the process continues–in fact, it has accelerated in the last year–Digital already is a much different company. It is more focused on competitive products and services, and on delivering significant value to its customers and business partners. By building on a history of technological innovation, Digital is delivering superior new products that will help make its customers more efficient and productive.



Digital's Alpha chip–a performance leader in the microprocessor industry.

The proof, of course, is in Digital's performance and ability to deliver value to its customers. The company is determined to be a profitable, growing company and the computing technology partner of choice for customers and business partners, as displayed by Chairman Robert B. Palmer in the core value statement:

"We have the ability–directly and through our partners–to implement and support networked platforms and applications in multivendor environments more quickly and cost effectively than anyone else.

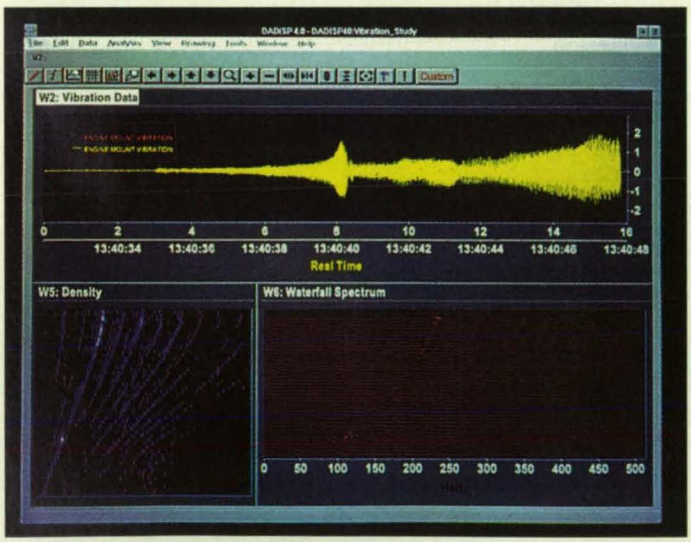
"This capability is making Digital the leader in open client/server computing–the combination of technologies that enables PCs, laptops, workstations and other devices to tap into computers so that these systems and the people who use them can share data and work together."

For more information about Digital, visit the World Wide Web at http://www.digital.com, or send E-mail to: moreinfo@digital.com.

For More Information Write In No. 766

DSP DEVELOPMENT CORPORATION

Data Acquisition, Analysis, and Visualization Software



If your working life is consumed by collecting, analyzing, visualizing, crunching, and reporting on your data, you should be interested in DADiSP. DADiSP is a visually-oriented software package for the display, management, analysis, and presentation of scientific and technical data. If you collect, manipulate, edit, reduce, transform, display, or analyze your data, *and you don't want to have to program*, DADiSP can handle and simplify your data needs. In short, DADiSP improves your day-to-day productivity. Point-and-click operations, icons, buttons, and pop-up menus let you choose from hundreds of functions. *We* could continue describing the product, but read what *customers* say, and then call for a FREE product trial:

- "...able to complete at least 50% more work in the same amount of time..."
- "The ability of DADiSP to provide custom time series data analysis without modifying or writing software makes the program a very powerful tool."
- "Simplicity itself to use. The graphical waveform processor equivalent of a powerful word processor. The use of DADiSP has dramatically decreased the time spent extracting and analyzing data."
- "There is a wealth of built-in functions available...the worksheets and types of analysis possible are virtually unlimited..."

Users in industry, government, and education have successfully applied DADiSP in the following areas: • data analysis • data acquisition and input • scientific visualization • data management • graphics • signal processing • statistical analysis • test and measurement • laboratory automation • experimental hypothesis testing • communications • medical research • image processing • quality management • process monitoring • physiology experiments • noise and vibration analysis • radar and sonar analysis.

Contact: DSP Development Corp., One Kendall Square, Cambridge, MA 02139; Tel: 617-577-1133; Fax: 617-577-8211; E-mail: info@dadisp.com; Internet: http://www.dadisp.com.

For More Information Write In No. 767

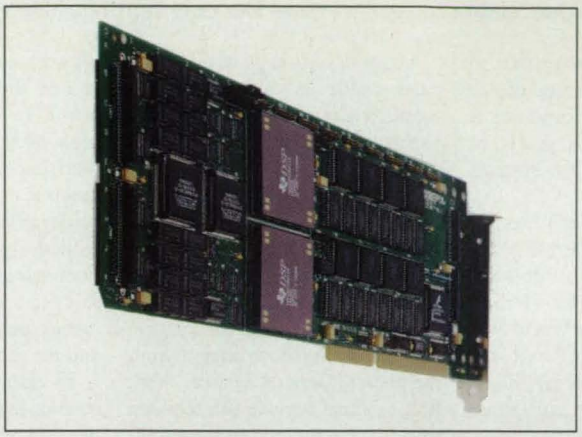
EPIX, INC.

Tomorrow's Imaging Today

EPIX provides state-of-the-art hardware and software to OEMs, system integrators, VARs, and end users in the image processing industry through its flexible image acquisition, processing, and display hardware and supporting software for PC/AT-compatible computers.

EPIX imaging boards and software interface to almost any video source, including video cameras, recorders, high-resolution and/or high-frame-rate cameras, line-scan cameras, and medical and graphical displays. User-customizable, menu-driven image analysis software for DOS and Windows provides morphology, blob analysis, motion analysis, densitometry, measurement, filtering, transforms, archiving, and annotation. C libraries are also available, providing comprehensive support for programmers.

The 4MEG VIDEO Model 12, available with 4, 16, or 64 Mbytes of on-board memory, features programmable memory configurations–high resolutions up to 31,000 pixels per line, or up to 16,000 lines; or lower resolutions for image sequences with over 65,000 frames–and 50-MHz capture and display rates using an internal or external pixel clock. Also featured is a 12-MIPS on-board digital signal processor which performs 12 million instructions per second.



The **IMAGE MEMORY EXPANSION** allows up to 256 Mbytes of image memory to be added to the Model 12 for real-time capture of 872 images, 640 pixels by 480 lines, storing 29 seconds of video at 30 fps! Image memory is upgradable to adapt to expanding applications. All features of the Model 12 are available with the addition of the **IMAGE MEMORY EXPANSION**, including sequential capture, configurable image buffers, programmable video formats, image display, and on-board processing. The **IMAGE MEMORY EXPANSION** supports all Model 12 camera interfaces operating at data rates between 2 MHz and 30 MHz.

The **COC402** (pictured) is designed to enhance the 4MEG VIDEO Model 12 board with additional processing power. The **COC402**, for the ISA (PC) bus, features two Texas Instruments 50-MHz, 32-bit, TMS320C40 digital signal processors. The **TMS320C40s** can perform parallel processing at up to 550 million operations per second. The **COC402** allows video-rate processing of basic operations and highly accelerated execution of complex operations. The **COC402** was designed to allow user-developed programs to be executed as quickly as possible. A combination of zero-wait-state static RAM (SRAM) for program storage and communication provides program execution at maximum speed.

Specialized area and line-scan camera interface cards and video multiplexers are also available.

For More Information Write In No. 768

GAGE APPLIED SCIENCES, INC.

Manufacturer of the World's Fastest PC-Based Data Acquisition Products

Gage Applied Sciences, Inc. was founded in 1987 by a group of Canadian engineers and entrepreneurs with a mandate of designing, manufacturing and marketing high-quality, high-speed data acquisition and instrumentation products based on the IBM PC platform.

Today, Gage is the recognized leader in the ultra-fast data acquisition market with its family of multi-MegaHertz A/D and D/A cards for the ISA bus.

World's Fastest 12 bit A/D Board

Gage manufactures the world's fastest 12 bit A/D system, the 60 MSPS **CompuScope 6012**, available on any platform.

Other products include the 250 MSPS **CompuScope 2125** and many other models which provide excellent performance at a reasonable price.

One of the most unique features of the CompuScope product line is the very deep data buffers it offers: up to 16 million samples. This allows the user to digitize an analog signal at very high speeds for a very long period of time.

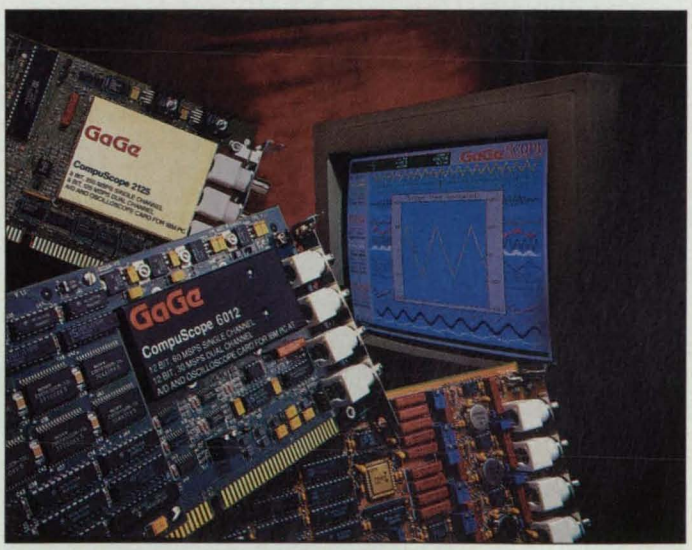
Software Support

In addition, Gage supplies its powerful **GageScope** scope-emulation software which can be used to evaluate the usefulness of a particular CompuScope card in an application without writing a single line of programming code! Drivers are also available for custom programming.

Applications

CompuScope cards have been used in many applications such as Non-Destructive Testing, Medical Ultrasound, LIDAR, Radar, Laser Doppler Anemometry, Telephony, Communications, etc.

The list keeps on expanding every day as scientists around the world figure out more ways of using computers to solve problems by analyzing digitized data.



Due to rapid expansion, Gage has relocated to a bigger factory space. The new address is:

Gage Applied Sciences, Inc., 5610 Bois Franc, Montreal, Quebec, Canada H4S 1A9; Tel: 1-800-567-GAGE or 514-337-6893; Fax: 514-337-8411; BBS: 514-337-4317; E-mail: prodinfo@gage-applied.com.

For More Information Write In No. 769

GENERAL DEVICES

Enclosures and Slides Meet critical Technical Requirements For Design Engineers

The technology required to develop and manufacture enclosure systems for electronic applications has progressed nearly as fast as the equipment the systems contain.

Forty-year-old General Devices first recognized the necessity for keeping up with components when company founder Herbert Fall, while serving as a World War II Naval officer, pioneered the telescoping slide, making "hard" rack-mounted equipment easier to access.

It was too obvious–slide the equipment to you for maintenance instead of completely disconnecting and removing from the rack.

General Devices uses flexible manufacturing methods to produce the basic components of Vent Rak® cabinets and racks. Standard components can be modified for unique applications: • custom vertical panel openings, panel widths or cabinet depths • specified access and control cutouts • structural reinforcements • special airflow provisions • low or very high level EMI/RFI shielding.

RFI/EMI CABINETS

Solving RFI/EMI problems is most effective at the point of origin, but in many cases, the solution must be found downstream from the source. General Devices' Vent Rak cabinets provide the required shielding attenuation to meet military or commercial testing applications. Vent Rak cabinets of steel or aluminum act as a barrier between emitter and susceptor of EMF. These enclosures provide shielding by reflecting and absorbing the electromagnetic radiation.

Normally, the shielding effectiveness of a solid conductor barrier (steel or aluminum enclosure welded along all seams) can be significant. However, it is not the limiting factor in achieving high shielding effectiveness. The amount of shielding achievable is controlled by barrier discontinuities such as apertures, seams, cable penetrations and air vents.

Shielding and cooling requirements demand air filters or vent panels that are opaque to EMI but still offer minimum resistance to air flow. Barrier discontinuities and seams are a necessary part of the enclosure design, which is also limited by production limitations, accessibility, and maintenance of the equipment to be mounted in the enclosure.

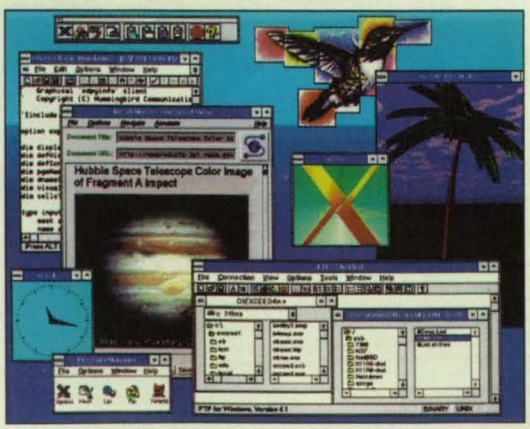
General Devices' enclosures and cabinets meet all military, commercial and consumer specifications governing EMI and RFI.

For More Information Write In No. 770

HUMMINGBIRD COMMUNICATIONS

Specializing in PC-to-mainframe communications services since 1984, Hummingbird began pioneering world-class PC X server software products in 1989. Its PC X products provide easy PC-to-UNIX and X Window System integration, making it possible for PC users to access the world of UNIX system functionality and features through a graphical user interface.

With the introduction of eXceed for Microsoft Windows PCs in 1991, Hummingbird became the first company to offer PC X servers for both the DOS and Microsoft Windows environments. In 1993, Hummingbird advanced its product line further with eXceed/NT, a Windows NT PC X server, and with eXceed/OS2, the first independent PC X server for OS/2. Hummingbird is the only company to offer PC X integration products for all four (DOS, Windows, Windows NT - Intel, MIPS, and Alpha, and OS/2) PC platforms.



Today, Hummingbird, headquartered in North York, Ontario, Canada, is a publicly traded company (on both TSE and NASDAQ) with over 175 employees and with offices in Mountain View, CA; Washington, DC; Geneva, Switzerland; Munich, Germany; Paris, France; and Leeds in the United Kingdom. Since its entrance into the PC X server market in 1989, Hummingbird has become a worldwide technology and market share leader, claiming the largest share of the PC X server market since 1991. The company has recently acquired Beame & Whiteside Software, recognized for its technology innovation and superior NFS solutions.

Hummingbird products are sold and supported in over 40 countries around the world–directly to major accounts and indirectly through major distributors and resellers. Supporting these efforts is a network of VARs, dealers and systems integrators.

Hummingbird offers the most comprehensive PC-to-UNIX integration product line available today. In addition to X servers for all major PC operating systems and user environments, its software family includes X Development Toolkits for Microsoft Windows, Windows NT, and IBM OS/2, and serial connectivity PC X server software for high-speed access to X hosts over telephone lines, an important capability in today's mobile and fast-paced business world. All products adhere tightly to industry standards.

Hummingbird maintains a Home Page on the World Wide Web. You may reach it at: http://www.hummingbird.com.

For more information, such as product reviews, corporate details, independent market analyses, or to obtain evaluation software, contact Hummingbird sales at: 1 Sparks Avenue, North York, Ontario, Canada M2H 2W1; Tel: 416-496-2200; Fax: 416-496-2207.

For More Information Write In No. 771

INTEGRATED ENGINEERING SOFTWARE

Integrated Engineering Software (Integrated), a Canadian research and development organization, provides the international engineering community and scientific firms with 2D/3D electromagnetic Computer-Aided Engineering (CAE) software tools. All programs are based on our unique Boundary Element Method (BEM) solution, one of the most powerful and advanced field solution algorithms available.

Programs enable research engineers in both large and small organizations to test various physical and material configurations, examine new design concepts, and optimize designs for a wide variety of electromagnetic applications prior to actually building a costly prototype.

CAE Program Packages

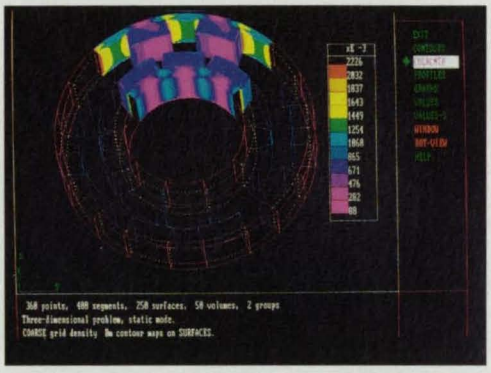
Integrated program packages include MAGNETO (2D/RS) and AMPERES (3D), magnetostatic field solvers; OERSTED (2D/RS) and FARADAY (3D), time-harmonic field solvers; ELECTRO (2D/RS) and COULOMB (3D), electrostatic field solvers; and KELVIN (2D/RS), a heat transfer analysis solver. Currently under development is LATTICE (2D), a spice model generator mainly used in the design and analysis of printed circuit boards.

Analysis and Design Applications

MAGNETO, AMPERES, OERSTED, and FARADAY are used for designing and analyzing electrical/electronic equipment such as solenoids, transformers, magnets, AC/DC motors, recording heads, and charging fixtures. These four programs also cater to linear, nonlinear, and permanent magnetic materials.

Use ELECTRO and COULOMB for the design and analysis of electrical/electronic equipment such as insulators, grounding electrodes, telecommunication cables, microstrip and integrated circuits, bushings, and transmission lines.

In addition to Integrated's electromagnetic analysis options, thermal analysis solver KELVIN is used for the design and analysis of heat transfer problems.



30-Day FREE Evaluation

Integrated offers a **30-day free evaluation** of all full version software to allow potential customers to test program capability with no obligation to purchase.

Fields which may have applications for Integrated products include the following: advanced materials, automation, computer hardware, defense industries, energy, manufacturing equipment and design, medical research, photonics and optics, scientific/laboratory equipment, subassemblies and components, telecommunications, transportation industries, etc.

Future Directions

The evolution of Integrated software depends, as Company President Dr. Y. Bulent Yildir states, on the needs of Integrated's diverse customer base. "For 10 years, Integrated has been a customer-driven company. To predict future enhancements to our current lineup of software, all one has to do is look at the future requirements of Integrated's customers."

Contact: Integrated Engineering Software, 46-1313 Border Place, Winnipeg, Manitoba, Canada R3H 0X4; Tel: 204-632-5636; Fax: 204-633-7780; E-mail: info@integrated.mb.ca.

For More Information Write In No. 772

IOTECH, INC.

Notebook & Desktop PC-Based Data Acquisition

IOtech, Inc. manufactures notebook and desktop PC-based data acquisition systems and IEEE 488 hardware and software for use in a wide variety of portable and stationary PC- and workstation-based applications. IOtech's parallel port-based portable data acquisition systems include PCMCIA and parallel port-based products that provide resolution from 100 kHz to 1 MHz and boast expansion channel capacities ranging from 72 to 256 channels. They are supported by an array of signal conditioning and expansion add-ons, including temperature, strain-gage, accelerometer, pressure, LVDT, high-voltage, current loop, isolation, filtering, simultaneous sample and hold, frequency, and digital I/O options.

IOtech recently introduced the WaveBook/512–the only 12-bit, 1-MHz notebook PC-based portable data acquisition product available. A DSP-based multichannel digitizer, the unit can acquire data at 1M sample/s over as many as 72 differential input channels. Its functionality and expandability, combined with its lightweight and compact 8.5" x 11" x 1.375" form factor, make it the ideal solution for cramped onboard test applications. A typical WaveBook/512 system for vibration-analysis test, replete with power and signal conditioning options, weighs less than 10 pounds and fits neatly into a briefcase for easy portability.

The WaveBook/512 is supported by an 8-channel simultaneous sample and hold card, an 8-channel programmable low-pass filter card, and an 8-channel dynamic signal input module. The WaveBook/512 and all associated expansion and signal conditioning hardware can be powered from an included AC adapter, or from any 10 to 30V source, such as a 12V car battery. IOtech offers an optional rechargeable battery/excitation module, the DBK30A, that provides up to 3.5 hours of portable operation.

IOtech's PC-based data acquisition products include graphical Windows setup and acquisition applications; DOS and Windows drivers for most popular programming languages; VBX custom controls; and support for third-party software packages such as Snap-Master, LABTECH NOTEBOOK, DASYLab, and LabVIEW.

For further information, contact: IOtech, 25971 Cannon Road, Cleveland, OH 44146; Tel: 216-439-4091; Fax: 216-439-4093.

For More Information Write In No. 773

THE MACNEAL-SCHWENDLER CORPORATION

The world standard in finite element analysis software

The MacNeal-Schwendler Corporation (MSC) is the leading developer of finite element analysis (FEA) software used in the field of computer-aided engineering. The Predictive Engineering approach–simulating the performance characteristics of a design before it is built or before a physical prototype is developed–has saved companies hundreds of millions of dollars in research, design, engineering, and manufacturing.

FEA is an analytical method used by engineers to help determine how well structural designs survive in real-world conditions such as stress, vibration, heat and electromagnetic fields and forces. FEA operates on the premise that a complex structure can be divided into smaller elements to form a finite element model simulating the structure's physical properties. The model is subjected to rigorous mathematical analysis. The results of the analysis can then be reviewed by the user in a variety of formats. From car horns to spark plugs to the Space Shuttle, FEA has significantly reduced the time and costs associated with prototyping and physical testing. It also helps ensure product performance, safety and reliability.

The MSC product line includes our core product, MSC/NASTRAN, a powerful, highly flexible analysis program on an open architecture for analyzing the stress, vibration, and heat transfer characteristics of structures and mechanical components. Other products include MSC/ARIES for full-function solid modeling and FEM and FEA pre- and post-processing; MSC/EMAS, an electromagnetic analysis system for electrical apparatus, EMC, RF & microwave, and antenna; MSC/DYTRAN, for solving highly nonlinear, transient dynamic problems; MSC/ABAQUS, for advance material models, special purpose finite elements, user specific routines, and coupled analysis procedures; and MSC/-PATRAN with geometry access and results visualization capabilities to provide an open system environment to integrate computer-aided design, test, and analysis software; MSC/MVISION–the Materials Software System for Visualization, Selection, Data Integration–enables engineers to work in a concurrent manner to choose and exploit materials as a design variable. MSC's newest products include MSC/NASTRAN for Windows, bringing the user the power of MSC/NASTRAN into a PC environment, and MSC/-NASTRAN for Pro/-ENGINEER.

All of MSC's software runs on a variety of platforms from PCs to supercomputers.

For More Information Write In No. 774

THE MATHWORKS, INC.

MATLAB® Technical Computing Environment

Now employing over 250 people, The MathWorks Inc. was founded in 1984 and is located in Natick, MA. The founders of The MathWorks recognized the need among engineers and scientists for more powerful computation environments beyond that represented by procedural languages such as Fortran.

In response to that need, they combined their expertise in mathematics, engineering, and computer science to develop MATLAB®, a high-performance technical computing environment that combines comprehensive math and graphics functionality with a powerful high-level language.

The MathWorks has also developed SIMULINK® for simulating nonlinear dynamic systems, Real-Time Workshop™ for real-time C code generation, and an extensive family of add-on products called toolboxes to meet the more specific needs of vertical-market scientific and engineering applications. Over 150,000 technical professionals today use MATLAB to explore, analyze, simulate, design, and solve their most complex and challenging problems.

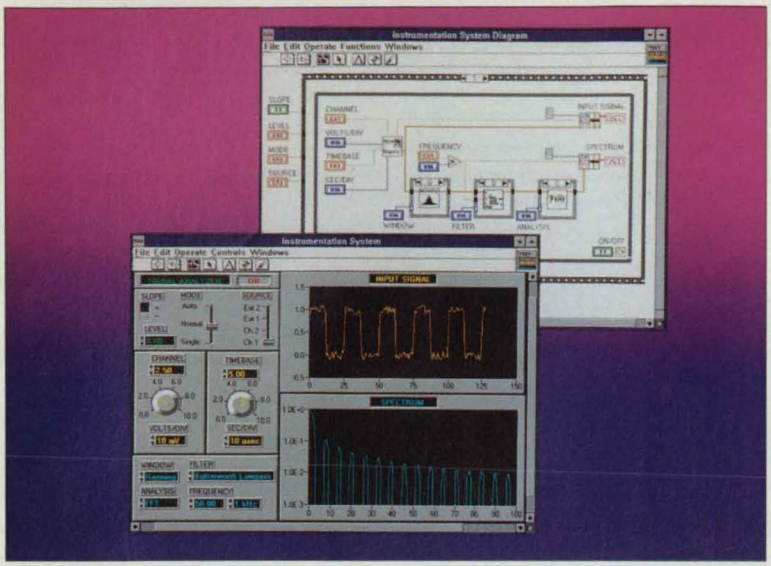
MATLAB, the underlying numeric computation foundation for all of The MathWorks products, combines hundreds of built-in mathematical functions with powerful 2D and 3D graphing capabilities. In addition, MATLAB offers an underlying programming environment that enables users to create their own functions in a fraction of the time required to write a program in Fortran, Basic, or C. MATLAB offers the convenience of an application package and the flexibility of a language to customize and add new functions as needed. These unique features have made MATLAB the industry standard for technical computing.

MATLAB has found widespread acceptance in diverse application areas where matrix theory plays an important role, such as signal processing, control system design, process identification, image processing, neural network design, and numerical analysis. The MATLAB application toolboxes have been created by renowned experts in their respective fields and represent theory and algorithms at the cutting edge of scientific and engineering research. This solid algorithmic foundation assures maximum efficiency and reliable results.

NASA engineers and scientists nationwide have adopted the MATLAB Technical Computing Environment for several mission-critical research and design projects, including the next-generation High Speed Civil Transport. For researchers who require performance and cannot afford to be limited to "black box" functionality, The MathWorks continues to design and develop products based on an "open architecture." This approach enables users to extend MATLAB for custom applications and to meet their specific requirements.

For More Information Write In No. 775

NATIONAL INSTRUMENTS



National Instruments is leading a revolution in instrumentation-the Virtual Instrumentation Revolution. With virtual instrumentation, personal computers and workstations are combined with software and hardware to build a powerful, but low-cost, instrumentation system. This complete system can consist of all the popular instrumentation alternatives, including plug-in data acquisition (DAQ) boards and GPIB, VXI, and RS-232 instruments.

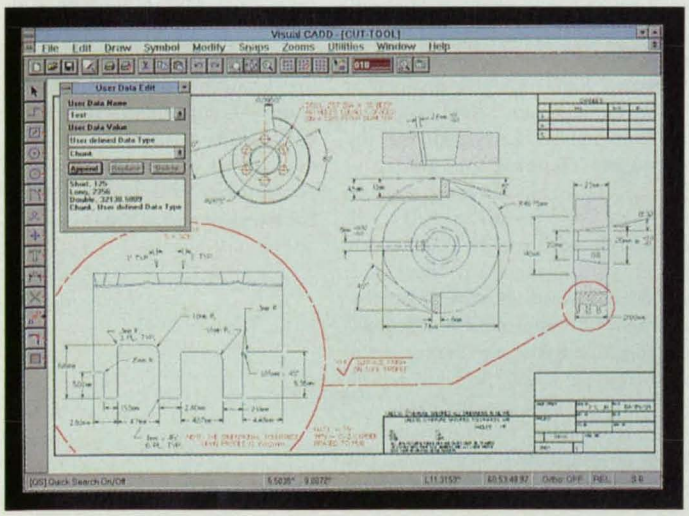
Founded in 1976, National Instruments today is a leading manufacturer of IEEE-488 interfaces, plug-in DAQ boards, VXIbus control-lers, and instrumentation software. National Instruments is dedicated to providing the highest quality products for data acquisition, data analysis, and instrument control. As part of our dedication to quality, in 1993 we announced a new organizational structure that is compatible with the guidelines from the ISO 9000 standards, ensuring that we deliver products and service of unequalled quality to our customers.

All of our products reflect the National Instruments commitment to high quality and innovation at a competitive price. We pledge to continue this commitment to you with investments in research and development that are well beyond industry norms. Likewise, our continued commitment to service will be demonstrated with a growing list of options for customer education and support.

For More Information Write In No. 776

NUMERA SOFTWARE CORPORATION

Numera Software Defines Ultra-Value Market



Numera is defining a new segment in the computer-aided design (CAD) industry–the "ULTRA-VALUE" market. The ultra-value CAD market lies between the retail market and the value market with typical prices under $1,000. The following key components define the ultra-value market: high-end features typically found only in very expensive CAD packages; open architecture that allows a broad variety of third-party developers to create custom solutions using industry-standard programming tools such as Visual Basic® and Visual C++™; file compatibility with currently used CAD applications; and superior customer service and technical support.

Numera Visual CADD 1.2 is designed to attract a wide variety of CAD users. It is the first Windows CAD package compatible with the Microsoft Office suite of business applications, making it the logical choice for the millions of Microsoft Office customers who need the precision and control that a CAD package offers. In addition, Visual CADD acts as an OLE 2.0 client, allowing linkage to a Word document or an Excel spreadsheet.

Visual CADD 1.2 offers several unique drawing features including: *Direct Distance,* which assigns an entity's length or size with a single key stroke; *tracking,* a navigational tool, referencing entities and locating points for edits, moves, and copying; and *matching,* which instantly extracts characteristics from any entity and applies them to the next command.

For more information, or to order Numera Visual CADD 1.2 directly, call: 800-956-CADD.

For More Information Write In No. 777

NYE LUBRICANTS INC.

Specialty Lubricants for Mechanical and Electromechanical Devices

Nye Lubricants designs and manufactures synthetic oils and greases that improve the efficiency and extend the operating life of highly engineered mechanical and electromechanical devices.

Founded as a whale oil enterprise in 1844, Nye began designing synthetic lubricants for OEM applications in the 1960s. The company maintains an extensive lubricant "drug store"–synthetic hydrocarbons, esters, polyglycols, silicones, polyphenyl and fluorinated ethers–and its engineers tap the different technical qualities of these functional fluids to deliver the best solutions to customers' design problems.

This approach to problem-solving has made Nye the vendor of choice for many of the world's most innovative component manufacturers. More than 50 Nye oils and greases are written into the specifications of US automobile manufacturers and their component suppliers; two specify only Nye synthetic greases in antilock braking systems and air bag connectors. In other industries, Nye lubricants are specified in many different products including aerospace bearings, optical instruments, medical instrumentation, telecommunication connectors, electrical controls, appliances and exercise equipment. In addition, leading computer and electronics manufacturers, NASA and the US military regularly turn to Nye for proprietary lubrication research projects.

Beyond their more than 400 synthetic oils and greases, Nye offers a unique array of specialty products, including fluorinated barrier films to control fluid and oil migration, ultraclean lubricants for precision ball bearings, and proprietary index-matching gels that are used as connecting media for fiber optic splices. Nye also maintains the most extensive line of motion control "damping greases," a cost-efficient way to build smooth, controlled, quiet motion into mechanical and electromechanical devices. Electrically conductive greases, sonic coupling fluids, heat sink compounds, vacuum greases and vacuum pump fluids round out their specialty products.

To learn more about Nye products and services, contact: Don Fairbanks, Nye Lubricants, PO Box 8927, New Bedford, MA 02742-8927; Tel: 508-996-6721; Fax: 508-997-5285.

For More Information Write In No. 778

RAG ELECTRONICS, INC.

Over 20 years ago, Richard A. Gertzman founded RAG Electronics. RAG was one of the first companies to **provide high-quality, cost-effective, used test equipment backed by a warranty.**

To ensure long-lasting, trouble-free used test equipment, RAG has developed a **rigorous reconditioning process**. In RAG's state-of-the-art lab, all units are **fully calibrated and certified traceable** to the NIST in accordance with MIL-STD-45662A. RAG provides all manuals, standard accessories, and a six-month parts and labor **warranty.**

Used equipment is now more popular than ever before. RAG sells to the U.S. Government, major universities, and primary and sub-contractors. Companies in all industries and sizes, from manufacturers to R&D firms and more.

RAG also **buys recent-model, pre-owned test equipment** such as RF and microwave equipment, spectrum analyzers, synthesizers, oscilloscopes, environmental chambers, power supplies and more. If you have equipment you're **no longer using**, you may find it advantageous to contact RAG and speak with someone in purchasing.

RAG is an authorized distributor of **new test equipment** from world-class manufacturers, including **Tektronix** and **Fluke**. New test equipment is in stock, **ready to ship today**.

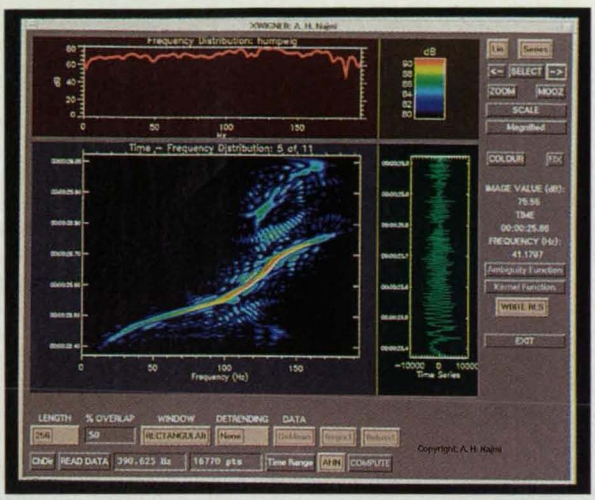
Providing **personalized service**, RAG assigns an expert RAG representative to meet your needs. RAG delivers the **fastest response** on quotes in the industry. If your requirement isn't in stock, RAG will **search nationwide** and quickly let you know what they find. With dozens of similar instruments on the market, a knowledgeable RAG sales engineer will help you select the right equipment for your application.

RAG's **free** catalog includes a wide range of instruments. The catalog subscription is free if you call at 1-800-455-3457 or fax them **at 1-800-272-4329**. Call if you have an upcoming requirement or you're looking for a specific item; RAG will gladly recommend the most **cost-effective solution**, fax the **data sheet** to you, and advise you of **price and availability**.

For More Information Write In No. 779

RESEARCH SYSTEMS, INC.

IDL 4.0 Offers Significant Enhancements in Math and Statistics, Scientific Functions, Programmability, and Documentation



IDL is an integrated computing environment for data analysis, visualization, and application development. IDL includes powerful image and signal processing routines, comprehensive 2D and 3D plotting, enhanced 3D visualization tools, hypertext on-line help, and extensive mathematics and statistics routines in the following areas: Curve and surface fitting, differential equations, eigensystems, FFTs and Wavelet transforms, multi-dimensional gridding, integration, linear systems, non-linear systems, optimization, special and transcendental functions, probability functions, correlation analysis, statistical fitting of data, hypothesis testing, multivariate analysis, frequency domain analysis, time series analysis and forecasting .

IDL's built-in interface controls allow engineers to build complete point-and-click applications that enable technicians and non-programmers to perform complex tasks. Also included are program debugging capabilities and tools for building IDL applications that maintain native hardware "look and feel." Organizations can continue to take advantage of their software investments by using IDL's links that allow users to call their external programs or call IDL as a graphics/plotting "engine" from their C or Fortran programs.

IDL is completely portable, giving users in heterogeneous labs confidence that their IDL applications will run the same no matter what their computer hardware. Personal computer versions include Windows, Windows NT, Macintosh, and native Power Macintosh. Workstation versions are available for DEC, HP, IBM, SGI, and Sun.

IDL prices range from $1500 to $3000.

For more information, contact: Research Systems, Inc., 2995 Wilderness Place, Boulder, CO 80301; Tel: 303-786-9900; Fax: 303-786-9909; E-mail: info@rsinc.com.

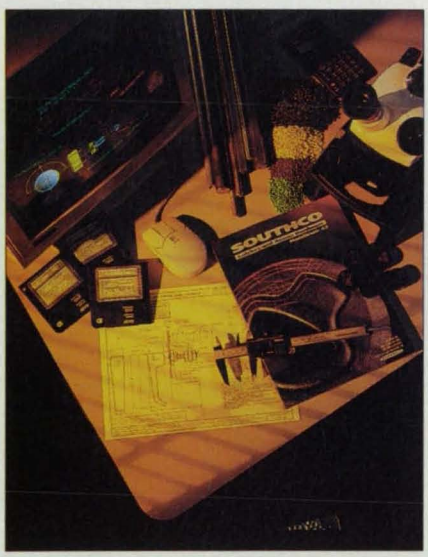
For More Information Write In No. 780

SOUTHCO, INC.

Southco, Inc. designs and manufactures industry's broadest line of latches and access hardware, offering value-added support such as:

- CAD drawing files of our products to facilitate your design efforts;
- Factory-trained field sales and engineering service–at your service!;
- Total Quality Management for consistently high-quality products;
- Fast samples to help in your testing efforts;
- Southco engineering recommendations to assist you;
- Product modifications and custom design expertise to provide precisely the solutions you want.

Southco has received some of industry's most prestigious awards for quality, which helps recognize our company-wide efforts to meet today's demands for excellence, as well as our commitment to TQM.



Southco's systematic, prevention-oriented quality management efforts include:

Corporate Quality Council. Top management fosters the importance of quality throughout the entire corporation through this council: giving direction, setting policies, and supporting the overall quality program.

Southco Quality Policy Manual. The comprehensive policy manual provides clear direction for the quality system and is supported by procedures and work instructions, giving every Southco employee the tools needed to take responsibility for quality.

ISO 9001. Southco is an ISO 9001 registered supplier.

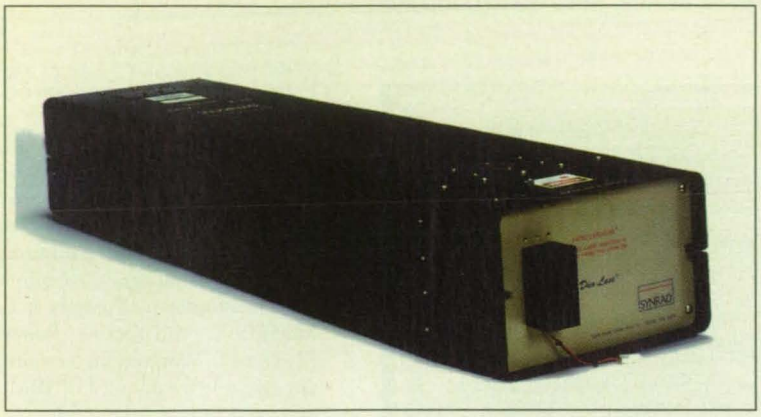
Statistical Process Control. Southco manufacturing processes employ stringent SPC methods to control quality from part-to-part and batch-to-batch. Each Southco operator, through in-house SPC training, becomes an authority on the process he or she controls.

Failure Mode Effects Analysis (FMEA). These preventive measures are conducted at the design and process stages to determine possible failures and their effects, before any customer buys the product.

For more information, contact: Southco, Inc., Brinton Lake Road, Concordville, PA 19331; Tel: 610-459-4000; Fax: 610-358-6314.

For More Information Write In No. 781

SYNRAD, INC.



Synrad, Inc., the world leader in sealed CO and CO_2 lasers, is proud of its technological achievements in its first 11 years. Synrad has grown from being a manufacturer of 10 and 25 watt CO_2 lasers to become the largest manufacturer of sealed CO and CO_2 lasers between 10 and 240W, as well as offering a full line of electro-optical components and subsystems for lasers with wavelengths ranging from excimer to CO_2. Synrad's latest innovation is the 60 Series laser, with output power up to 240W (pictured).

Synrad, Inc. was founded in 1984 by Peter Laakmann to do advanced research in electro-optics, including gas lasers. Synrad research and development resulted in a new implementation of radio frequency (RF) excited plasma section that paved the way for higher quality CO_2 and CO sealed-off lasers at much lower cost.

Synrad's CO and CO_2 lasers are built using a basic family of modules that are incorporated into all of the power levels, from 10 to 300W. The plasma discharge section and housing are aluminum extrusion. This patented "all-metal" technology allows for mass production and low costs, and translates into superior quality lasers at a fraction of the price of competing lasers.

The competitive advantage enjoyed by Synrad has resulted in a sustained growth rate of over 50% in sales over the last few years. This impressive growth continues in 1995, in part due to the increasing number of new users of laser technology. Synrad CO and CO_2 lasers are an inexpensive and reliable alternative to existing mechanical tools such as hot knives, dies, routers, blades, milling machines, saws, etc. CO and CO_2 laser applications include cutting, marking, drilling, and heat treating of most non-metals, as well as engraving of anodized aluminum.

For More Information Write In No. 782

GOVERNMENT TECHNOLOGY SERVICES, INC. (GTSI®)

Uniting Government With Technology

GTSI is the leading reseller to the Federal Government of microcomputer and UNIX workstation hardware, software and networking products from the largest selection of brand-name manufacturers. GTSI specializes in offering a variety of mobile, desktop and engineering workstation computing solutions and cross-platform integration services for DOS/Windows, UNIX-RISC and Macintosh-based networking solutions. GTSI sells directly and indirectly to all departments and agencies of the Federal Government, many state and local governments, and hundreds of system integrators and prime contractors that sell to the government market.

In 1994, GTSI acquired Falcon Microsystems, which for ten years had been the leading reseller of Apple and other products to the government. This merger allows GTSI to offer its customers more products, services and expertise than ever before.

GTSI provides about 40,000 products from over 400 manufacturers and is recognized as a true one-stop shop for technology-based solutions. GTSI makes these products available through a variety of important procurement vehicles such as GSA Schedules A and B/C, the Air Force Desktop IV contract, Navy Companion contract, Army Portables-1 contract, and the NASA SEWP contract.

GTSI has continued to expand its NASA SEWP contract and has added a variety of major product lines to provide NASA with a robust product offering of software, peripherals, x-terminals and multi-function products. New products include Apple Power Mac systems configured to provide full x-terminal functionality, Netscape, Oracle, ESRI and a variety of software product lines; a full spectrum of printer and storage solutions, as well as a variety of telemetry products. In addition to all NASA centers, the contract is available to NASA contractors under cost-reimbursement contracts.

In 1995, GTSI unveiled GTSI Online–the first on-line service to provide electronic selection, ordering and payment of personal computer and workstation products for the government marketplace. GTSI Online puts over 15,000 products–GTSI's entire contract offering–on your desktop.

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continued from page 80

Chilling the inert gas produces two additional benefits: one is the creation of an ultradense inert atmosphere around the welds; the other is that the chilled gas cools the metal more quickly down to a temperature at which the metals are not reactive. The report describes experimental welds made on aluminum in ambient air, under helium purge, and under chilled-helium purge. While a vast improvement was obtained by use of the helium purge, a further improvement was obtained by use of the chilled-helium purge.

This work was done by William F. McGee and Daniel J. Rybicki of Martin Marietta for **Marshall Space Flight Center**. *To obtain a copy of the report, "Super Chilled Root Side Purging,"* ***write in 60*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-31010.

Mathematics and Information Sciences

Numerical Stability in Hyperbolic Boundary-Value Problems

A technical memorandum discusses the stability of numerical solutions involving semidiscrete approximations to hyperbolic partial differential equations in initial-and-boundary-value problems. This is a topic of practical significance because hyperbolic partial differential equations arise in the mathematical modeling of waves and blasts. Solutions are often needed over restricted regions of what would otherwise be unbounded spaces. The outer boundaries are then artificial, introduced only to limit the domains of the numerical solutions. The conditions at such artificial boundaries can cause numerical instabilities that degrade the computed solutions.

The solution of the semidiscrete approximation requires an extrapolation of the difference equation at the boundary where the boundary condition is not specified for the partial differential equation. This requires a numerical-boundary-condition scheme. The improper treatment of the numerical boundary conditions can cause numerical instability even though the semidiscrete approximation is stable for the pure initial-value or Cauchy problem.

This work was done by Robert F. Warming and Richard M. Beam of **Ames Research Center**. *To obtain a copy of the report, "Stability of Semidiscrete Approximations for Hyperbolic Initial-Boundary-Value Problems: Stationary Modes,"* ***write in 21*** *on the TSP Request Card. ARC-12265*

Finite-Element Modeling for Structural Analysis

A report presents a study of finite-element mathematical modeling as used in analyzing stresses and strains at joints between thin, shell-like components (e.g., ducts) and thicker components (e.g., flanges or engine blocks). As a result of the study, two basic approaches were suggested for determining correct values of stresses and strains. The first approach is to use a global/local model to evaluate the system. This provides the correct total response and a correct representation of stresses away from any discontinuities. The global model involves a coarse computational mesh; to minimize the cost of computation, finer meshes are used only to compute responses in local regions of interest. The second approach involves the development of special transition finite elements to model the transitions between shells and thicker structural components.

This work was done by J. B. Min and S. G. Androlake for **Marshall Space Flight Center**. *To obtain a copy of the report, "An Assessment of Finite-Element Modeling Techniques for Thick-Solid/Thin-Shell Joints Analysis,"* ***write in 82*** *on the TSP Request Card. MFS-28971*

Constraint-Based Scheduling System

A report describes the continuing development of software for a constraint-based scheduling system that is to be implemented eventually on a massively parallel computer. The system is based on machine learning as a means of improving scheduling. The system is designed to learn when to change its search strategy by analyzing its search progress and learning the general conditions under which a resource bottleneck is likely to occur.

This work was done by Monte Zweben and Megan Eskey of **Ames Research Center**; *Todd Stock, Will Taylor, Bob Kanefsky, and Ellen Drascher of Sterling Software; Michael Deale of Lockheed Engineering and Sciences Co.; and Brian Daun and Gene Davis of RECOM Technologies. To obtain a copy of the report, "Constraint Based Scheduling,"* ***write in 25*** *on the TSP Request Card. ARC-13215*

Physical Sciences

Calibration of Partial-Pressure-of-Oxygen Sensors

A report and analysis of, and discussion of improvements in, a procedure for calibrating partial-pressure-of-oxygen sensors to satisfy Spacelab calibration requirements has been released. The sensors exhibit fast drift, which results in a short calibration period that is not suitable for Spacelab. By assessing the complete process of determining the total drift range available, the calibration procedure was modified to eliminate errors and still satisfy requirements without compromising the integrity of the system. The calibration period was extended from 32 days to over 90 days. The modified procedure involves bench calibration rather than expensive late mission-flow processing.

This work was done by David W. Yount and Kevin Heronimus of McDonnell Douglas Aerospace for **Marshall Space Flight Center**. *To obtain a copy of the report, "Calibration Period Process for Spacelab PPO2 Sensors,"* ***write in 20*** *on the TSP Request Card. MFS-31039*

More About Measuring Interfacial Tension Between Liquids

A report presents additional discussion of a technique for measuring the interfacial tension between two immiscible liquids. The technique was described in "Measuring Interfacial Tension Between Immiscible Liquids" (LEW-15855), *NASA Tech Briefs*, Vol. 19, No. 1 (January, 1995), page 60.

This work was done by Nasser Rashidnia of NYMA, Inc.; R. Balasubramaniam of Case Western Reserve University; and David M. Del Signore of the University of Toledo for **Lewis Research Center**. *To obtain a copy of the report, "Liquid-Liquid Interfacial Tension Measurement Using a Capillary Tube,"* ***write in 3*** *on the TSP Request Card. LEW-15811*

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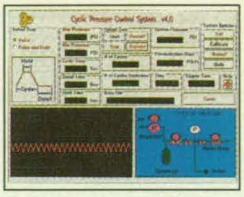

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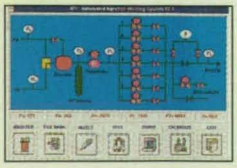

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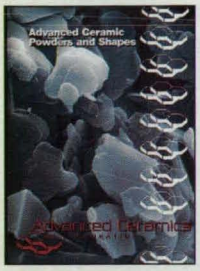

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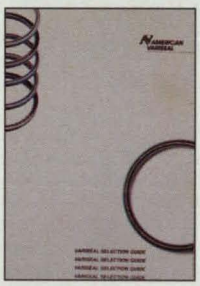

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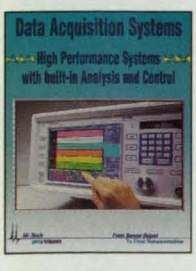

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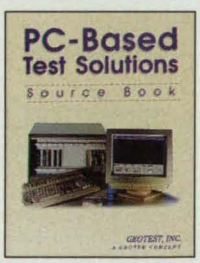

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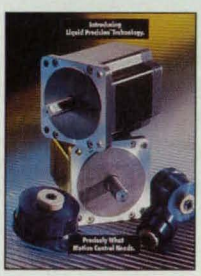

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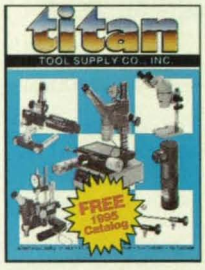

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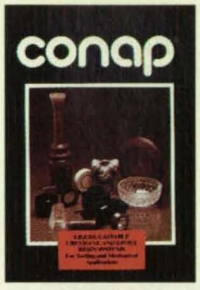

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Hardigg Cases offers over 225 standard rotationally molded transit cases, including a full line of 19" EIA rack mount cases, deck cases, and flangemount cases. Hardigg's expert engineering, manufacturing, and test facilities provide start to finish custom design capability. A complete list of standard cases allows for rapid delivery...as few as three working days! Take advantage of over forty years of experience...design a Hardigg case into your next project!

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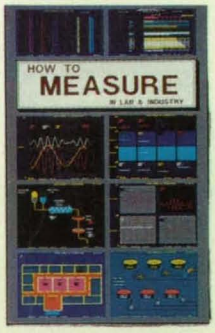
PORTAGE ELECTRIC PRODUCTS INTRODUCES CONDENSED PRODUCT GUIDE

This new mini-guide to the wide-ranging line of PEPI thermal controls contains a fast-reading overview of twenty-four different creep-action and snap-action devices. All PEPI thermostats and thermal protectors can be customized to fit particular applications. For further information, contact Portage Electric Products, Inc.; Tel: 216-499-2727; 770 Freedom Ave. NW, PO Box 2170, North Canton, OH 44720; Fax: 216-499-1853.

Portage Electric Products, Inc.

For More Information Write In No. 330



HIGH RESOLUTION DATA ACQUISITION

FREE booklet shows many ways to automate data collection using your personal computer. It comes with a FREE Instatrend Real-Time Graphics Demo Disk. Dianachart, Inc., 101 Round Hill Drive, Rockaway, NJ 07866. Tel: 201-625-2299.

Dianachart, Inc.

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ETREMA Products Inc.

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1995 PCMCIA PRODUCTS CATALOG

The new PCMCIA-PC CARD standard has brought many new devices such as Video Capture, 16-bit Stereo, CD-ROM, Pager, and mini PC Card Camera Cards. ENVOY DATA has released its new catalog with these products plus many others like: Memory, I/O (serial, parallel, SCSI, A/D, etc.) with Industrial Card and Drives, Multimedia, Industrial, and Engineering tools for PCMCIA applications. Tel: 602-892-0954; Fax: 602-892-0029. 953 E. Juanita Ave., #A, Mesa, AZ 85204.

Envoy Data Corporation

For More Information Write In No. 333

MECHANICAL COMPONENTS

PIC Design's new Catalog 43 is bigger than ever--288 pages including new Modular Framing Elements, Linear Motion Systems & Positioning Tables and expanded lines of Lead Screws & Nuts, Belts & Pulleys, Ball Slides, Shoulder Screws, Bearings, Shafting, Couplings and much more. PO Box 1004, Middlebury, CT 06762. Tel: 800-243-6125; Fax: 203-758-8271.

PIC Design

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The Grieve Corporation

For More Information Write In No. 336

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Published monthly, this new CD-ROM contains key engineering patents from all disciplines. Designed to help innovative organizations track competitive developments, identify new applications and save on design and production time.

Derwent North America

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"HANDS-ON" ADVANCED COMPOSITE WORKSHOPS—SINCE 1983

The brochure describes 13 different "hands-on" workshops in advanced composite materials technology. These workshops cover fabrication, repair, manufacturing, tooling, blueprint reading, adhesive bonding, ultrasonic inspection of composites, and 4 engineering workshops. Emphasis is placed on prepreg carbon and aramid fiber materials and processes, utilizing vacuum bagging and high-temperature curing methods in the oven and autoclave. Three workshops are Canadian DOT approved. REFRESHER WORKSHOPS OFFERED. For a free brochure, call 1-800-638-8441; Fax: 702-827-6599.

Abaris Training Resources

For More Information Write In No. 338

1995 ROGAN KNOB CATALOG

The complete lineup of Rogan knobs and dials--including a range of new offerings--is featured in their new fully illustrated catalog. New products included in this edition are several new Pure Touch Knobs™ such as clamping knobs in an expanded range of sizes, the all new five-lobe clamping knob and raised bar pointer knob. ROGAN CORPORATION, 3455 Woodhead Drive, Northbrook, IL 60062; Tel: 800-423-1543; Fax: 708-498-2334.

Rogan Corporation

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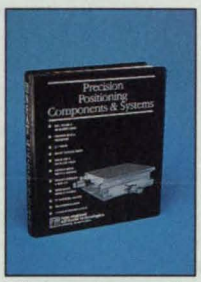

POSITIONING/ MOTION CONTROL CATALOG

NEW, detailed 160 page catalog covers NEAT's expanding line of precision positioning and motion control components and systems. Featured are single axis, X-Y, multi-axis, rotary, high vacuum, air bearing, and microscope stages. NEAT also provides a complementary line of stepping and servometer drives and controls. NEAT specializes in providing modified, custom, and turnkey SOLUTIONS to a wide range of positioning and motion control applications. Please contact our Sales Engineers at 800-227-1066, or send E-mail to neat@tiac.net for more information.

New England Affiliated Technologies

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GENESYS BOROSCOPES & ENDOSCOPES

Genesys Instruments, Inc. designs and manufactures boroscopes and endoscopes for the health care and industrial markets at highly competitive prices. This NEW brochure features standard scopes for immediate shipment, as well as custom design and protyping services for any precision optical product specifications. Genesys Instruments is ready with quick service, support and delivery. Call 800-839-9038 for your FREE BROCHURE! Genesys Instruments, Inc., 120 Carando Drive, Springfield, MA 01104; Fax: 413-788-7784.

Genesys Instruments

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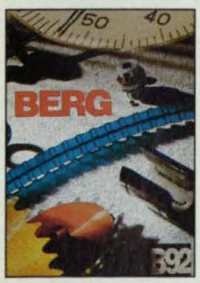

B92 CATALOG RELEASE

The latest catalog from W.M. Berg, Inc., coincides with Berg's silver anniversary. Founded in 1967, Berg has grown to become a recognized industrial leader of miniature precision mechanical components. A significant number of new items are added as well as expanding previous product lines. Featuring 50,000 standard components, 80% of which we are able to ship from stock within 24 hours. Available in metric version too: M92. Tel: 516-596-1700; Fax: 516-599-3274.

W.M. Berg

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INSTRUMENTS FOR DATA ACQUISITION AND CONTROL

New Daytronic catalog describes "intelligent" data acquisition instruments that perform all required signal conditioning tasks, and can evaluate acquired data and initiate necessary actions for real-time process control. Higher-level instruments can also serve as high-speed computer front ends in a network environment. Daytronic Corporation; Tel: 513-866-3300; Fax: 513-866-3327.

Daytronic Corporation

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ELECTRO-MAGNETIC DESIGN SOFTWARE

The legendary Vector Fields suite of software, including the TOSCA, ELEKTRA and OPERA packages, combines classical finite element techniques with user friendly interactive graphics for high accuracy 2D and 3D simulation and design of all types of electromagnetic equipment.

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AFFORDABLE VACUUM ACCESSORIES

New vacuum accessories catalog features over 800 affordable products including flanges, fittings, construction components, valves, vacuum gauges and residual gas analyzers. These high quality products are backed by Balzers technical service and support. In-stock items are shipped within 48 hours. Visa and MasterCard are accepted. Balzers, 8 Sagamore Park Road, Hudson, NH 03051; Tel: 603-889-6888; Fax: 800-555-3173; for orders toll-free: 800-555-3172.

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Climax Specialty Metals

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MOTORS THAT SURVIVE

Empire Magnetics' catalog "Motors That Survive," features specialized motors for hostile application environments. The 42-page catalog highlights the company's 1.8° stepper motors, brushless motors, gearboxes, brakes and resolvers for use in harsh environments that are destructive to ordinary motors. Motor versions are rated for vacuum, radiation, high temperature, cryogenic, wet, abrasive, dusty, oily, and corrosive conditions. Tel: 707-584-2801; Fax: 707-584-3418.

Empire Magnetics Inc.

For More Information Write In No. 347

STATICIDE SOLVES STATIC CONTROL PROBLEMS

STATICIDE, a highly effective topical method for controlling static electricity, is designed for commercial and industrial uses. Available in concentrate, general purpose and heavy duty formulas for long-term static control applications, STATICIDE is non-toxic, non-flammable, non-staining, completely biodegradable and safe for all surfaces. Tel: 800-782-8420.

ACL Incorporated

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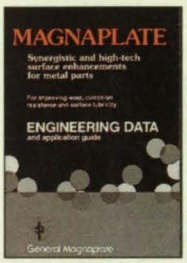

COATINGS RESIST ABRASION AND CORROSION

Magnaplate-applied abrasion and corrosion-resistant coatings for metal parts are detailed in 8-page Engineering Data Guide. Hardness, friction, wear, temperature, thickness and corrosion and abrasion resistance properties of 13 super-hard, non-stick, permanent, surface-enhancing coatings are described. Also includes applications and FDA/USDA approvals. General Magnaplate Corp., 1331 Route 1, Linden, NJ 07036; Tel: 800-852-3301 or 908-862-6200; Fax: 908-862-6110.

General Magnaplate Corp.

For More Information Write In No. 349

BROCHURE FEATURES FLEXIBLE BORESCOPES

Visual inspections are easy with a flexible borescope. Machida, Inc. offers a line of flexible borescopes for various industrial inspections. With insertion tube lengths from 1 to 20 feet and diameters from .5mm to 12.5mm, Machida borescopes can accommodate most inspections. Flexible borescopes include an angulating tip for accessibility to different views. Machida also carries engine inspection kits, blending borescopes, video systems, light sources and borescope accessories. Machida, Inc.; Tel: 800-431-5420.

Machida, Inc.

For More Information Write In No. 350

FREE DESIGN AID

Save layout time and eliminate detailing with this 16 page Template catalog. This catalog shows FULL SIZE drawings of many tooling components used in designing jigs and fixtures. It includes Spring & Ball Plungers, Nuts, Bolts, Washers, Knobs and many other items, all with sizes and part numbers. Also included will be a copy of the current catalog listing these and additional items, along with prices. Northwestern Tools, Inc., 3130 Valleywood Drive, Dayton, OH 45429; Tel: 513-298-9994; Fax: 513-298-3715.

Northwestern Tools, Inc.

For More Information Write In No. 351

A new PRODUCT SELECTION GUIDE to advanced composite prepregs from ICI Fiberite, Tempe, AZ, presents an overview of the resins, fibers and fabrics used to manufacture the company's preimpregnated unidirectional tape, fabrics, and tow. The 20-page guide also lists average mechanical properties for 350° F epoxy prepregs, 350° F toughened epoxy prepregs, 350° F cyanate ester materials, and thermoplastic prepregs as well as 250° F epoxy and phenolic prepregs. ICI Fiberite, 2055 E. Technology Cir., Tempe, AZ 85284; Tel: 602-730-2234.

ICI Fiberite

For More Information Write In No. 352

FIRESTONE CONTEST ENTRY KIT

Win $2,000 in Firestone Industrial Product Company's 1995 Innovators Design Contest. The free Entry Kit contains information on Firestone's Airstroke® actuators and Airmount® isolators, design problem-solver sheets, entry sheets, contest rules and a *Firestone Engineering Manual & Design Guide.* One grand-prize winner receives $2,000, two first-place winners receive $1,000 each and two second-place winners receive $500 each. Deadline: December 31, 1995. Fax name and address to: Firestone Innovators Design Contest, c/o CRE, Inc., 317-631-0272, or call 800-888-0650. E-mail: Firestone@industry.net.

Firestone

For More Information Write In No. 353

KEITHLEY CONTAMINANT MONITOR

Keithley's new Quantox™ oxide charge monitoring system, based on Corona-Oxide-Semiconductor (COS) technology, measures oxide parameters cost-effectively, including mobile oxide charge, thickness, effective charge, flatband voltage, interface state density, and type tests. It monitors parameters immediately after the monitored process step. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139; Tel: 800-552-1115; Fax: 216-498-2911.

Keithley Instruments, Inc.

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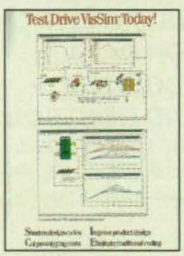

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The SCRAMNet® Network, a real-time communications system based on a replicated shared-memory concept, is optimized for the high-speed transfer of data among computers. Applications include simulation, telemetry and virtual reality. Call for this FREE application summary. SYSTRAN Corp. Tel: 800-252-5601; Fax: 513-258-2729; E-mail: info@systran.com.

SYSTRAN Corp.

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PeakFit separates and characterizes unresolved peaks in data using sophisticated nonlinear curve-fitting techniques. PeakFit offers 30 functions for peak analysis of spectroscopy, chromatography, pharmacology, engineering, statistics, and other data. Graphical control of parameter values enables you to manipulate individual peaks. PeakFit generates numeric and statistical summaries and curve-fit graphs, which can be printed or exported.

Jandel Scientific Software

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MCM ELECTRONICS OFFERS NEW 332 PAGE CATALOG, FREE!

MCM is the industry leader in the distribution of consumer electronic repair parts and accessories. Catalog #35 contains more than 21,000 items including TV/VCR and appliance repair parts, semiconductors, speakers, test equipment, computer products and more. All items are in stock and ready to ship from distribution centers near Reno, NV and Dayton, OH, allowing two-day shipping to most of the continental U.S., at ground rates. Call toll free: 800-543-4330. TB01.

MCM Electronics

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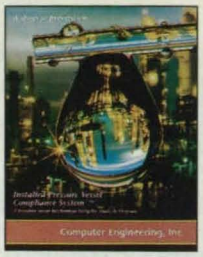

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Computer Engineering, Inc.

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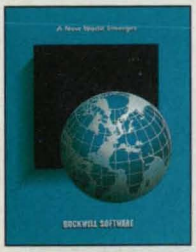

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Rockwell Software Inc.

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NEW 1995-96 COLE-PARMER® INSTRUMENTS CATALOG

The new, free 1995-96 Cole-Parmer instruments catalog contains over 1700 full-color pages and features more than 40,000 products covering scientific instruments, equipment, and supplies. The catalog includes a detailed 40-page product index and table of contents, informative introductory pages for many of the catalog sections, "Hot Tips," and an 8-page section of late-breaking products. Contact Cole-Parmer Instrument Company—in the USA or Canada, call toll-free 1-800-323-4340.

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For More Information Write In No. 363

ENGINEERING SOLUTIONS FOR MAGNETIC SHIELDING

Ad-Vance Magnetics has released their newest engineering catalog featuring 25 solutions to magnetic shielding problems, basic relationship between E and H vectors, calculation support in shield design, enhanced skin effect and technical article reprints. Ad-Vance Magnetics, 625 Monroe St., Rochester, IN 46975; Tel: 219-223-3158; Fax: 219-223-2524.

Ad-Vance Magnetics

For More Information Write In No. 364

CD-ROM CATALOG—WORKBENCHES AND SYSTEMS

This interactive multi-media presentation covers Teclab's workbenches and laboratory systems furniture. Designed for Windows™, the CD-ROM presentation features hundreds of benches. *Meeting the Challenge*, Teclab's introductory video, highlights unique features and benefits of a Teclab bench. Select what you want by clicking on the icons that interest you. Teclab, Kalamazoo Technical Furniture, 6450 Valley Industrial Drive, Kalamazoo, MI 49009; Tel: 800-832-5227; Fax: 616-372-6116.

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DCC Corp.

For More Information Write In No. 366

NEW VIDEO SHOWS HOW TO PREDICT LAB RESULTS WITH FEA

Finite Element Analysis In Action! is a new kind of instructional video for engineers. Live lab and computer demonstrations show how to better use any FEA software. A case study of brittle fracture--which can happen to almost any material, even steel--provides real-world examples. Two lab experiments and two FEA anaylses are conducted and the results compared. Demonstrates specific modeling and analysis techniques for predicting lab results with FEA.

APD

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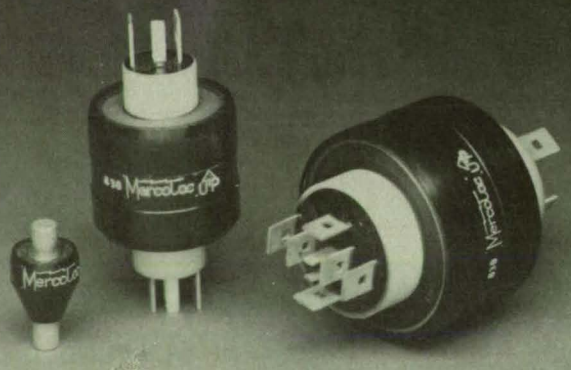

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For More Information Write In No. 424

New on the Market

Product of the Month

The SmartMotor™ line of **drives** from Baldor Electric Co., Fort Smith, AR, combines adjustable speed control electronics with an industrial motor in one package. Advantages include guaranteed motor-control compatibility, easy installation, and elimination of the panel space previously needed for a stand-alone inverter. The drive design reduces line voltage reflections that contribute to premature motor failure in adjustable speed drive applications. Ranging from 1 to 10 horsepower in NEMA standard frame sizes, the initial units meet FCC standards for radio frequency interference (RFI).

For More Information Write In No. 700

NuVision Technologies Inc., Beaverton, OR, has released the SGS 19S stereoscopic **3D display kit** for use with a monochrome or full-color monitor. Comprised of a liquid crystal modulator, viewing glasses, and driver box, the kit produces stereoscopic 3D images by alternately displaying left and right eye images. The modulator mounted on the monitor encodes the images with circular polarization. The glasses decode the images, providing the 3D display. Applications include 3D computer graphics, inspection systems, molecular and solids modeling, and scientific visualization.

For More Information Write In No. 701

SICK Optic-Electronic Inc., Eden Prairie, MN, has introduced the FGS Flexible Guarding System, a self-contained, noncontacting light curtain that features a 2" x 2" cross-section and nominal protective heights from 12" to 72" in 6" increments. Designed for use on hazardous machines for point-of-operation, area, perimeter, or entry/exit guarding, the curtain allows unrestricted access while providing control-reliable safeguarding. Resolutions of 14 or 30 mm and scanning ranges to 60' are provided.

For More Information Write In No. 704

The SuperView 100 **video windows model** from RGB Spectrum, Alameda, CA, combines a high-resolution workstation screen with four simultaneous, live video windows on a single monitor or projector. Designed for applications requiring simultaneous display of video and graphics, the system is compatible with any workstation to 1280x1024 pixels. Users can insert up to four live video images in real time. Inputs from cameras, recorders, and teleconferencing systems are accepted.

For More Information Write In No. 702

The Model TJE **pressure transducer** from Sensotec Inc., Columbus, OH, provides 0.1% FS accuracy over a pressure range from 1 to 60,000 psi. Featuring all-welded stainless steel construction, the transducer has an operating temperature range from -73.3° C to 163° C. Options include compensated temperature ranges, pressure ports, electrical terminations, and an intrinsically safe internal amplifier.

For More Information Write In No. 705

Mectrol Corp., Salem, NH, has introduced the RS Series **rotary actuators**. A urethane timing belt forms two air-sealed loops between the two parallel end-plates of the actuator case. Directed air pressure expands either loop, pulling the belt from the other loop past a seal, rotating an output shaft. Features include shock-free starts and stops; no backlash or bounce-back; adjustable travel stops; and no leakage.

For More Information Write In No. 703

Lighthouse Digital Inc., Grass Valley, CA, has introduced generic, solid-state **data communications matrix switchers** that provide switching of any input to any or all outputs. Switching is non-protocol-dependent and I/O connectors can be copper or fiber optic. Signal data rates in 50 Mbs maximum, 500 Mbs maximum, and 1.5 Gbs maximum bandwidths are available. Applications include data acquisition networks and digital video and audio.

For More Information Write In No. 706

New on the Market

Metrum, Littleton, CO, has introduced a variable data rate/high-capacity **digital data acquisition recorder** with sustained transfer rates from 0 to 64 Mb/sec., and the ability to store a 27.4 or 20.8 Gb single tape cassette. Record times range from 57 minutes and 44 minutes at 64 Mb/sec. to 76 hours at 800 Kb/sec., depending on the data rate and type of tape cassette. The recorder is available in a standard 19" rack-mount configuration and can be used for ASW, telecommunications, telemetry, flight test, and digital video/imaging applications.

For More Information Write In No. 707

The Model 250 23-bit **data acquisition system** from Lawson Labs Inc., Kalispell, MT, features 22-bit monotonicity, linearity at 0.001% of full scale, and sampling rates over 5 kHz. The system combines a RISC microcontroller with a multi-pass, A/D conversion architecture to achieve DC accuracy at high sample rates. At maximum speed, effective resolution is 19.5 bits. The system can operate as a polled or scanning A/D and interfaces to a host computer via a standard parallel port. Using external multiplexers, up to 96 channels can be sequentially scanned.

For More Information Write In No. 708

Cyberware, Monterey, CA, has introduced the WB2 and WB4 3D **whole-body scanners** for product designers, CAD/CAM, research, medical appliance design, anthropometry, and ergonomics applications. In as little as 12 seconds, the units scan the entire human body in color and 3D. The scanners use two or four scanning instruments mounted on vertical towers; with a person standing on either scanner's platform, the instruments move down from the head to scan the body. Workstation software controls the scanning and motion operations, with scans from each system combined into a complete 3D model.

For More Information Write In No. 709

A line of temperature-responsive **bellows assemblies** from Servometer Corp., Cedar Grove, NJ, are custom designed, manufactured and assembled to measure response over a temperature range of 66° C to -45.6° C. The lightweight assemblies are thin-walled, electrodeposited nickel bellows that are soldered to custom end pieces. The bellows is filled and sealed with a working fluid having a known coefficient of thermal expansion. When the temperature of the filled bellows changes, the volumetric expansion of the fluid is translated into linear motion, per degree change in temperature.

For More Information Write In No. 710

The CX100 precision **frame grabber** for OEM, industrial, and scientific applications from ImageNation Corp., Beaverton, OR, has a sampling jitter of ±3nS and video noise less than one LSB. It features crystal-controlled timing for image accuracy and repeatability, and digital synchronization for compatibility with standard resettable cameras and VCRs. Image transfer rate is 1 Mb per second. A software interface, C library with source code, and Windows DLLs for C developers and Visual Basic developers are provided.

For More Information Write In No. 711

Super Emotia™ and Super Emotia GX high-resolution **PC-to-video scan converters** are available from Extron Electronics, Anaheim, CA. Users can record computer-generated video to videotape, and can produce display of VGA, Super VGA, XGA PC and Mac video on video-only LCD projectors and monitors. The systems feature horizontal and vertical shift, freeze frame, and overscan/underscan switch. They require no special software or hardware for installation. The Super Emotia GX adds a genlock sync input and component video output.

For More Information Write In No. 712

nuLogic Inc., Needham, MA, has introduced the FlexMotion **servo and stepper motor control board** with up to ten complete motion axes in a single PC ISA slot. The FIFO bus interface and command set provide high-speed communications, while off-loading complex motion functions from the host PC. The board provides two, four, or six axes of servo control, with two axes of stepper control. An optional two- or four-axis daughter card is available in servo or stepper configurations.

For More Information Write In No. 713

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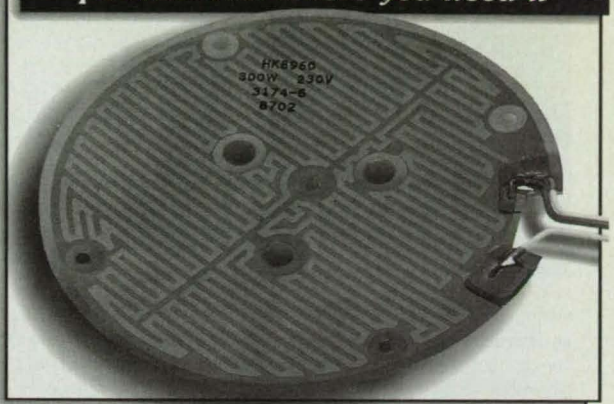

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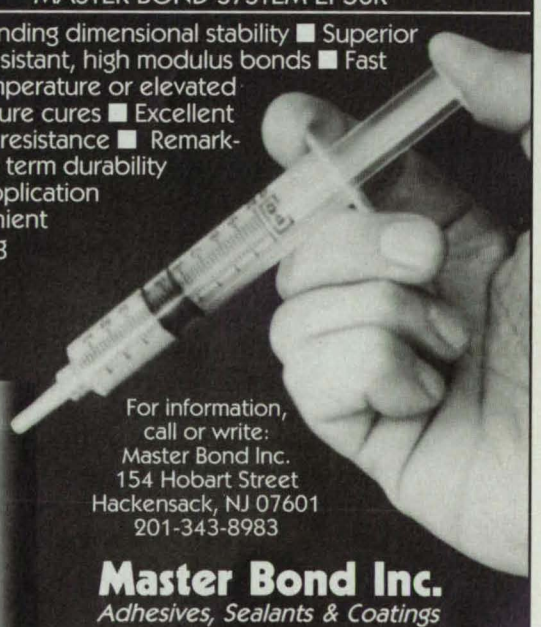

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For More Information Write In No. 431

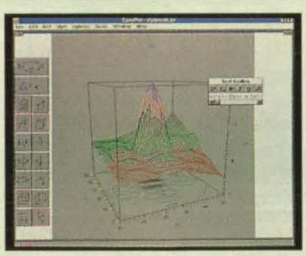
New on Disk

Pointwise Inc., Fort Worth, TX, has announced Gridgen Version 10 **structured grid generator software** combining a user interface with grid generation techniques for numerical simulations such as computational fluid dynamics (CFD). Gridgen offers a suite of tools with which the space on and around a CAD-designed product can be discretized. The cost is $5000 for a perpetual right-to-use license.

For More Information Write In No. 730

Production ResponseAgent™ Release 1.0 intelligent **manufacturing planning and scheduling software** has been introduced by Red Pepper Software Co., San Mateo, CA, to generate optimized plans, monitor critical manufacturing variables, alert users to problems as they arise, and recommend optimized solutions in real time. The ResponseAgents continuously monitor and alert users to changes in conditions. System prices begin at $150,000.

For More Information Write In No. 731

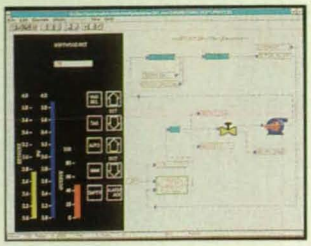


Spiral Software, Brookline, MA, has introduced EasyPlot Version 3 **data visualization and analysis software**, featuring 3D graphing, image plots, 3D curve fitting, a programming interface, on-line help, and a Preferences dialogue that provides access to power-user features. The Windows version costs $399; DOS, $349; and a DOS/Windows bundle, $449.

For More Information Write In No. 732

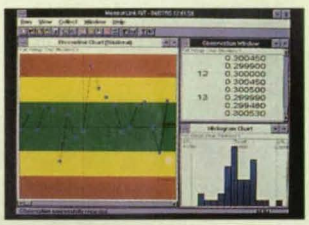
Matra Datavision, Andover, MA, has announced STRIM Professional Solutions Version 6 **styling, prototyping, tooling, and plastic analysis software** featuring a new user interface based on the OSF/MOTIF standard. The styling application combines a free-form surface modeler and photorealistic imagery to produce complex shapes. Prices begin at $11,500.

For More Information Write In No. 733



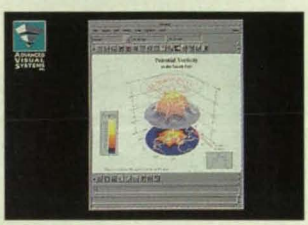
VisSim Version 2.0 from Visual Solutions, Westford, MA, is an upgrade to its **modeling and nonlinear simulation software**. New features include a Man Machine Interface display mode for operator training, an Animate block for drawing, design tools, and printing enhancements. The program runs in Windows, Windows NT, and UNIX operating systems. Prices range from $495 to $4195.

For More Information Write In No. 734



Mitutoyo/MTI Corp., Aurora, IL, has introduced MeasurLink™ real-time **data acquisition software** that allows immediate measuring data analysis and feedback. The Windows-based program establishes a database of part feature characteristics that can include notes and pictures.

For More Information Write In No. 735



Gsharp™ **graphing software** from Advanced Visual Systems, Waltham, MA, automatically creates 2D and 3D graphs from complex, recurring visual data. Designed for applications requiring precise graph layout, Gsharp creates graphs interactively and turns them into reusable macros. Prices begin at $4,800.

For More Information Write In No. 736

MINITAB for Windows Release 10 Xtra **statistical software** has been introduced by Minitab Inc., State College, PA. The program includes Microsoft's Win32s system, providing faster processing speed without upgrades. Features are zone control charts, short run, and run charts. Prices are $495 for academic customers; $895 for commercial customers.

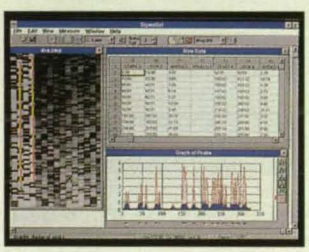
For More Information Write In No. 737

IGES Data Analysis, Melrose Park, IL, has announced version 1.5 of CALSVIEW **graphics viewing and markup software** for 2D and 3D CAD, legacy raster data, technical illustrations, plot files, and scanned images. Data files can be accessed from any system, and users can view data graphically from any angle, check distances, create comments on files, interrogate drawing entities, and convert to various output formats. A programming interface allows integration with product data management systems. Prices start at $595.

For More Information Write In No. 738

Robochart Versions 2.0 and 8.0 **flow diagram editing software** from Digital Insight, Simi Valley, CA, are designed for creation and modification of all types of flow diagrams. They feature an expanded library of more than 250 object shapes and 30 arrow types, unlimited label size and diagram complexity, a command-line printing facility, and a hypertext linking feature. User-defined objects can be outline or image formats.The first floating license is $850; additional licenses are $395 each.

For More Information Write In No. 739

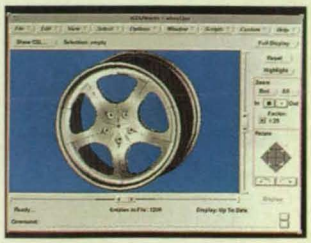


Jandel Scientific, San Rafael, CA, has released SigmaGel for Windows **electrophoretic gel analysis software** that analyzes electrophoretic gels on a PC. Spatial, intensity, and/or molecular weight calibrations can be set or loaded for each image. Features include lane, spot, and molecular weight measurement modes; a built-in spreadsheet and graph window; and DNA sequence graphs with text files of the results. The program costs $495.

For More Information Write In No. 750

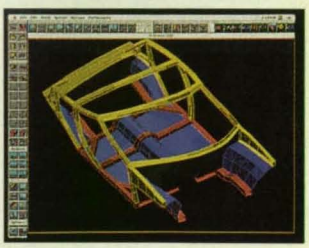
Version 2.2 of HiQ **numerical analysis and data visualization application software** from National Instruments, Austin, TX, includes an improved user interface, controls, and indicators such as switches and buttons, data communication capabilities, high-resolution printing, and automation features. Users can build interactive analysis, simulation, and modeling applications using data fitting, linear algebra, signal processing, statistics, and differential equations. The cost is $695.

For More Information Write In No. 751



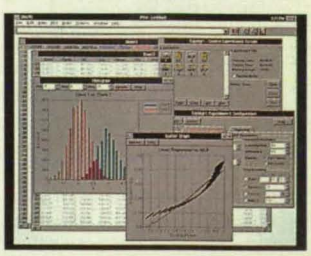
International TechneGroup Inc., Milford, OH, has introduced IGES/Works® Version 3.0 **data exchange software** that reads IGES files from any source, allowing users to view, analyze, edit, and transfer the data to any other CAD/CAM/CAE system. Enhancements include solids display, data reduction, GUI recorder, geometry analysis, and surface reversal.

For More Information Write In No. 752



LapFEA 3D **stress and vibration analysis software** for Power Macintosh from LAPCAD Engineering, San Diego, CA, performs 3D stress and vibration analysis of structures, components, and mechanical systems. Included are solid and transparent layering, manual and automatic meshing, animation, contour mapping, and cross-sectional analysis. Applications include product design/analysis, manufacturing methods, process design, packaging, instrumentation, and thermal systems/devices. Prices range from $295 to $795.

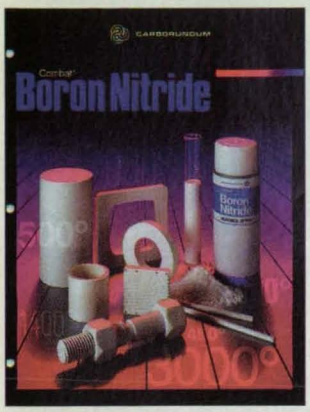
For More Information Write In No. 753



Pattern Recognition Workbench **neural network modeling and pattern recognition software** from Unica Technologies Inc., Brighton, MA, integrates a proprietary spreadsheet for interactive data processing, and an experiment manager to manage neural network modeling and pattern classification experiments. Manufacturing engineers and researchers can use the program to analyze and improve manufacturing aspects on PCs, and DEC and Sun workstations. Prices start at $3,495.

For More Information Write In No. 754

New Literature



Combat® Boron Nitride, a **synthetic ceramic material**, is described in a 12-page brochure from The Carborundum Co., Amherst, NY. The material is available in solid, powder, liquid, and aerosol spray forms for products in thermal, mechanical, chemical, and electrical applications. Resisting temperatures to 3000° C, it has a dielectric strength of nearly 2300 volts per mil, and can be machined to close tolerances without firing.

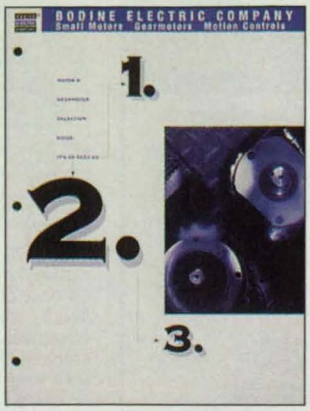
For More Information Write In No. 720

Hottinger Baldwin Measurements, Marlboro, MA, offers an eight-page brochure describing its **inductive displacement transducers**. The devices are used for research and development, production engineering, safety, and quality assurance applications, where safety, compact size, high resolution, and accuracy are required.

For More Information Write in No. 721

Humphrey Inc., San Diego, CA, has released a 24-page catalog of **guidance and control system instruments** such as gyroscopes, vertical indicators, rate sensors, position transducers, accelerometers, power supplies, and magnetometers. Applications include aerospace, oceanography, the military, and general industry.

For More Information Write In No. 722



A brochure from Bodine Electric Co., Chicago, IL, includes flow charts and conversion tables for selecting **motors and gearmotors**. Methods for calculating speed and torque for various applications are included.

For More Information Write In No. 723

Penn Engineering & Manufacturing Corp., Danboro, PA, has released a 20-page catalog of Standard Insert® **threaded inserts for plastics**, including ultrasonic, molded, and post-molded threaded inserts in brass, stainless steel, and aluminum. The inserts offer an alternative to typical joining methods such as adhesives or traditional hardware.

For More Information Write In No. 724

The Micro Slides Division of Anorad Corp., Hauppauge, NY, has released a 20-page catalog of **positioning systems and components**. It describes crossed roller bearings, ways, slide assemblies, linear position stages, positioning controllers, and rotary positioning stages.

For More Information Write In No. 725

Detroit Tool Industries, Madison Heights, MI, has released a brochure on Spiralock® **locking threaded fasteners and thread forms**. Tapped holes or fasteners using the thread forms can accept any standard male bolt and are reusable.

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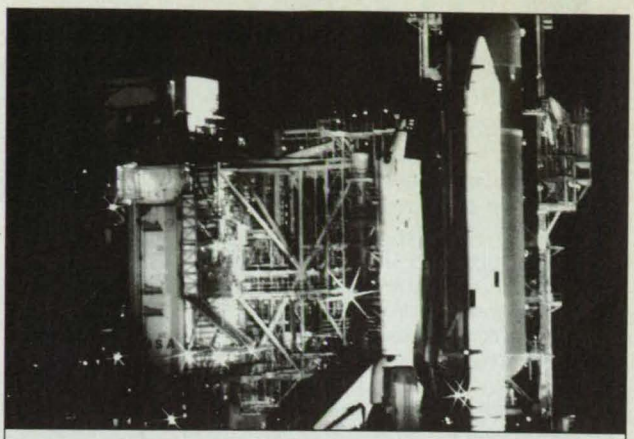

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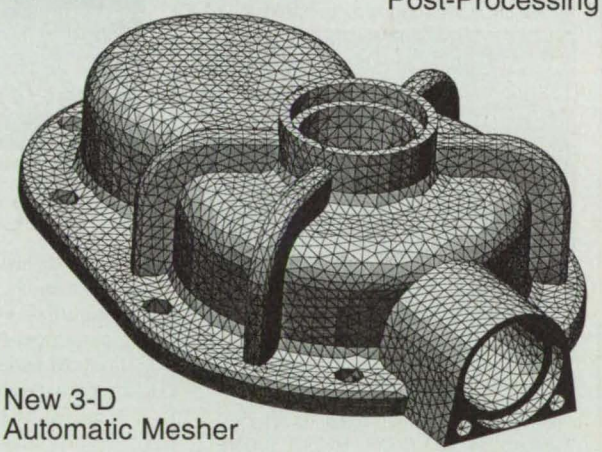

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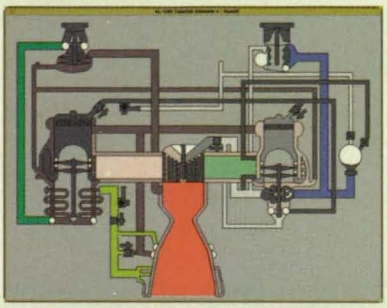

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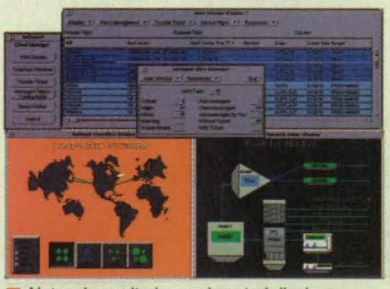
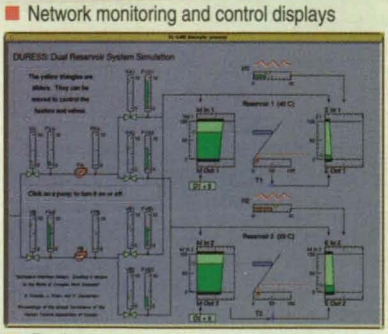


■ Network monitoring and control displays



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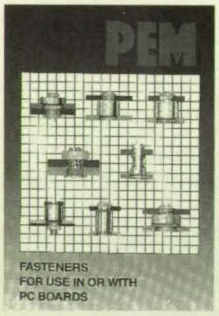

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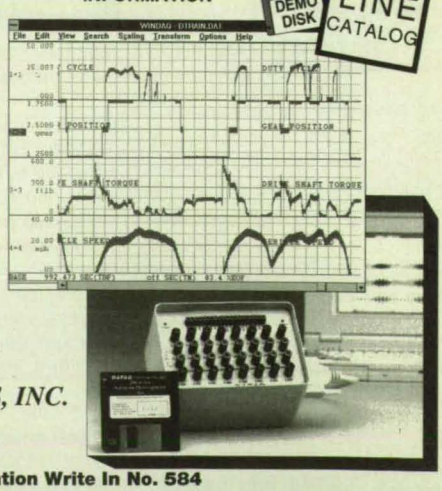

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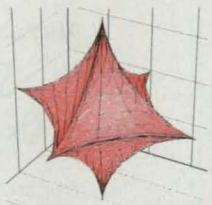

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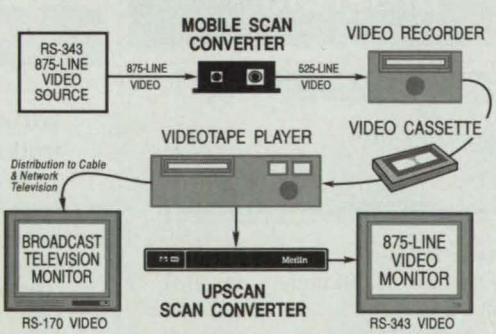

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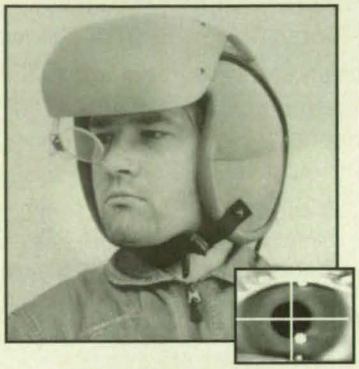

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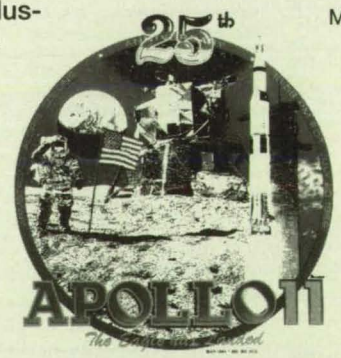

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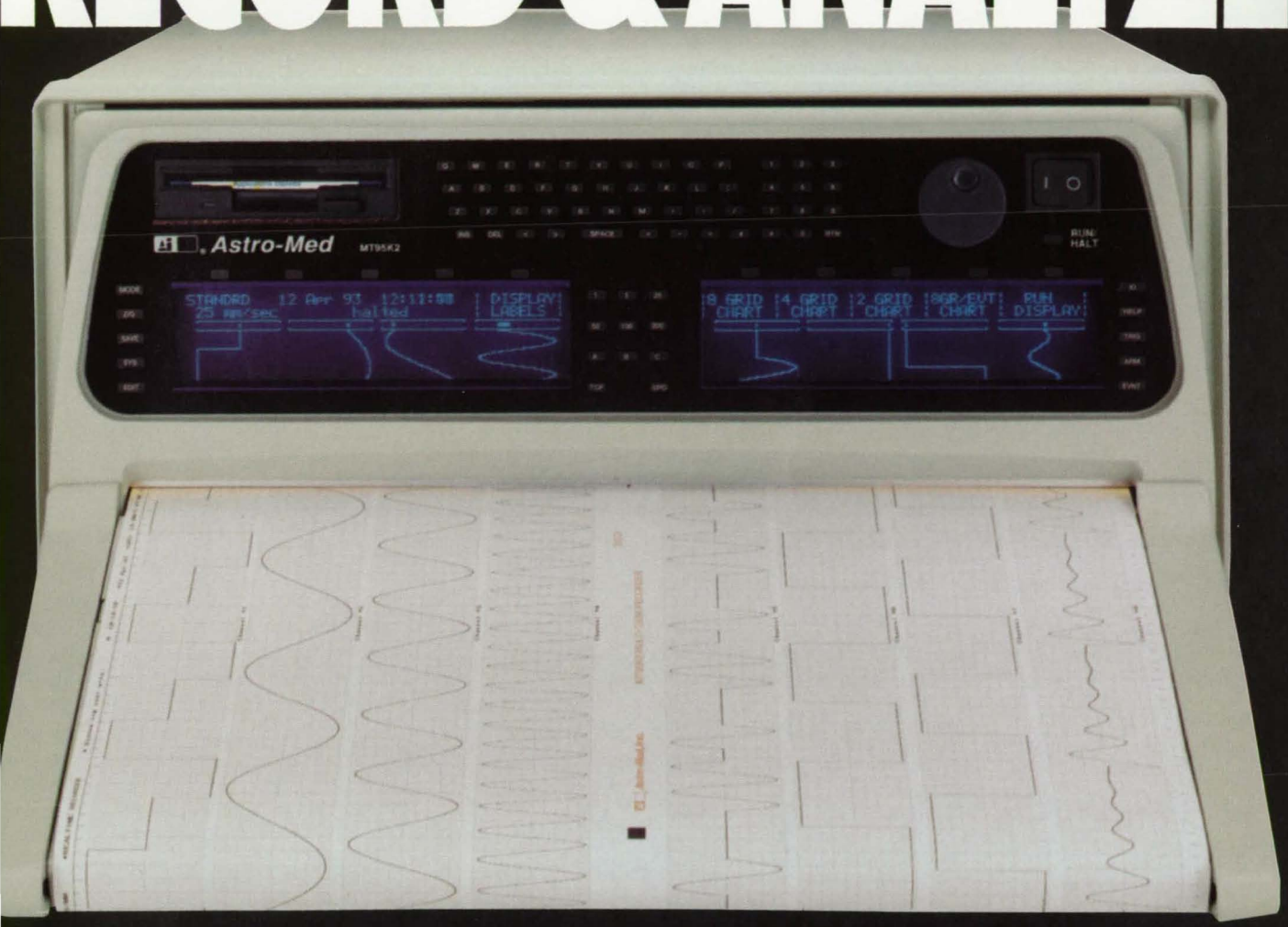

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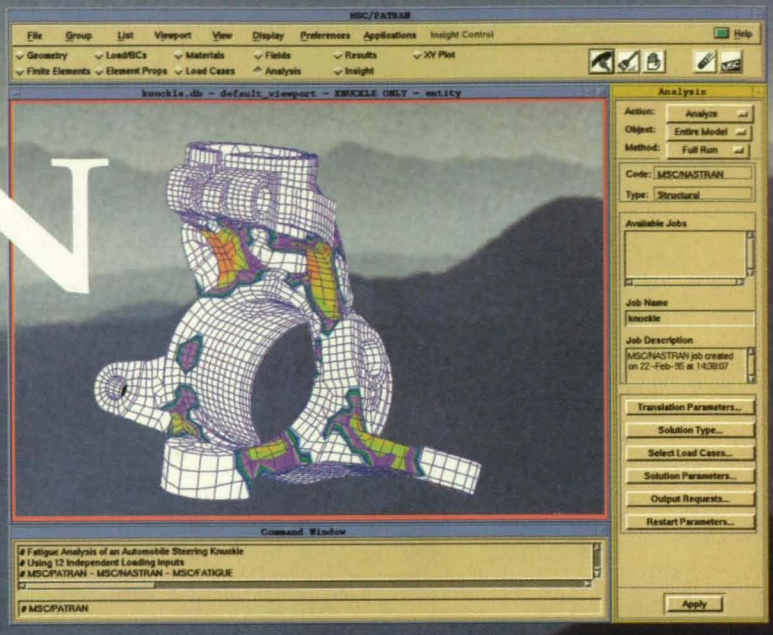

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